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**Evaluation of electronic prescription implementation in polymedicated users of Catalonia, Spain**

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**Word count:** 3,071

## ABSTRACT

**Objectives:** Electronic prescribing is a comprehensive health management tool that aims to provide advantages regarding quality, accessibility, safety, efficiency, continuity of care, and rational drug use. Drug use indicators in the general population and polymedicated patients in the public healthcare system were analysed before and after the implementation.

**Design:** 16 months of retrospective study followed by 12 months of prospective monitoring.

**Setting:** Primary healthcare in Barcelona Health Region, Catalonia, Spain.

**Participants:** All insured patients, especially those who are polymedicated in 6 basic health areas. Polymedicated patients were those with a consumption of  $\geq 16$  drugs/month.

**Interventions:** Monitoring demographic and consumption variables obtained from the records of prescriptions dispensed in pharmacies and charged to the public health system, as well as the resulting drug use indicators. Territorial variables related to implementation of electronic prescribing were also described and were obtained from the institutional data related to the deployment of the project.

**Main outcome measures:** Trend in drug use indicators (number of prescriptions per polymedicated user, total cost per polymedicated user and total cost per prescription) according to e-prescription implementation.

**Results:** There was a significant upward trend in the number of polymedicated users, number of prescriptions and total cost ( $p < 0.05$ ), which seemed independent from the implementation of electronic prescribing when comparing the pre and post implementation period. Prescriptions per user, cost per user and cost per prescription showed a decrease between the pre and post implementation period, being significant for cost per prescription ( $p < 0.05$ ).

**Conclusions:** Results suggest that after the implementation of electronic prescribing, drug use indicators decreased in polymedicated patients. In addition, this study provides a very valuable approach for future impact assessment.

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**Strengths and limitations of this study**

- This is a novel study that describes the implementation of an e-prescribing system in polymedicated users. It establishes many drug use indicators (demographic and consumption variables) and represents a very important step towards an integral and integrated pharmaceutical management in health services.
- An economic impact study could not be carried out because it was still too early to attribute all observed changes to electronic prescriptions because its integration into all elements of the health system was not fully completed at the time of study.
- This is the first report showing results of drug use indicators in polymedicated patients with e-prescriptions. It provides a very valuable approach for future impact assessment.

## INTRODUCTION

Rec@t is the electronic prescription system in the autonomous region of Catalonia (north-eastern Spain).<sup>1</sup> The Catalan Health Service has played an active part leading the development of the project, as guarantor of public health services that purchases and evaluates healthcare depending on the needs of the population. The Catalan healthcare model is decentralised, to better know the health needs of the population and develop a better relationship with providers in each health region and their respective Basic Health Areas (BHAs). BHAs are the basic territorial units around which primary healthcare services are organised (areas or municipalities), according to the population's access to the services and the efficiency in organising health resources.<sup>1 2</sup>

Rec@t is a strategic healthcare project that aims to provide advantages concerning quality, accessibility, safety, efficiency, continuity of care, and rational drug use.<sup>3</sup> The implementation of this system is a comprehensive health management tool that addresses the entire process involved in pharmaceutical services. This includes everything, from prescribing and dispensing in community pharmacies to the assessment and payment of the benefit.<sup>4</sup>

It entails a different healthcare model than it had thus far, highlighting in particular the elimination of paper-based prescribing. The key element that helps serve this task is the medication plan,<sup>1</sup> which is the printed sheet that is given to patients and contains all the information necessary to be able to follow the treatment correctly (i.e. dose and frequency of administration). It facilitates the feedback between prescribers and dispensers, forming a new communication channel between them and helping to prevent medication errors and duplicities of treatment.<sup>3 5-7</sup> Therefore, electronic prescribing is an important tool to control chronic patients, the elderly and polymedicated users, who generate the greatest interest because of their therapeutic complexity, high drug consumption and total cost for the healthcare system.<sup>8 9</sup>

Rec@t implementation began in 2007 after an initial pilot experience in 2006 that proved the feasibility of the designed system. The progressive extension of electronic prescriptions started, reaching 100% of the equipment in late 2010.<sup>3</sup> Currently, it is considered fully complete in primary care, and in specialty care it has reached significant levels on the extent and volume of prescriptions issued and dispensed, so it is expected to be completed this year.<sup>10</sup> Community pharmacies completely work with electronic prescribing, given that more than 90% of prescriptions dispensed are already in electronic format. More than 12,500 physicians who have joined the system so far

have made prescriptions to more than 5 million patients, reaching 275 million medications dispensed.<sup>1 10</sup>

Regarding other Spanish autonomous regions, similar projects in electronic prescribing were already underway in primary care at the same time as Catalonia. The most advanced of which were in Andalusia (southern Spain),<sup>11</sup> and in Balearic Islands (eastern Spain).<sup>12</sup> At an international level, it is noteworthy to mention experiences in Denmark,<sup>13</sup> Sweden,<sup>11</sup> and England,<sup>11 14</sup> where healthcare organizations are involved in improving quality of prescriptions through e-prescribing systems along with Spain.<sup>10</sup> The ultimate goal of these experiences is to be brought into a single overall system allowing interoperability in the near future, both nationally and throughout Europe.<sup>10 15</sup>

The aim of our study was to analyse drug use indicators in the general population and polymedicated patients receiving sixteen or more medications in the public healthcare system in the Barcelona Health Region (BHR), both before and after the implementation of the electronic prescription system.

**METHOD**

**Design and setting of the study**

Interventional study in a primary care setting, conducted on the general population and polymedicated patients in those BHAs in BHR with the greatest cumulative grade of implementation in e-prescription between May and December of 2009. Monitoring included 16 months of retrospective study (January 2008-April 2009) and 12 months of prospective follow-up from the beginning of the implementation of Rec@t in BHR (May 2009) to April 2010. This was considered a sufficiently large analysis for the objectives to be achieved (28 months).

A polymedicated user in the present study was defined as someone receiving 16 or more active principles in a month,<sup>17</sup> according to drug use indicators in primary care evaluated by the Catalan Health Service.

**Data source**

The study used population data from 2008, 2009 and 2010 Catalonia censuses.<sup>18</sup> Records of billed prescriptions were also utilized, based on both paper and electronic prescriptions that were dispensed in community pharmacies and charged to the Catalan Health Service. This information was obtained by means of the personal healthcare

card, the document that provides citizens with access to the centres, services and benefits of the public health system (these services include drugs subsidised by the Catalan Health Service).<sup>1</sup> This information is stored monthly in a computer system, which allows the design and gathering of information required for the management and monitoring of pharmaceutical services.

### Variables of the study

The variables used to analyze the implementation of e-prescription were as follows.

**Territorial:** number and % of BHAs implemented, % of primary care centres implemented, grade of implementation, number of general practitioners (e-prescription prescribers), % of general practitioners implemented, number of community pharmacies which dispensed electronic prescriptions and % of community pharmacies implemented. Grade of implementation is the percentage of electronic prescribing on the total number of prescriptions billed (sum of prescriptions on paper and electronic format) for a given month or a specific time period (cumulative implementation grade). Depending on the variable described, the grade of implementation is indicative of the deployment of electronic prescription in the territory (i.e. in a given BHA) or the percentage of electronic prescriptions prescribed to an individual in a given period.

**Demographic:** number and % of users implemented, % of users with more than 50% of electronic prescriptions and % of users with more than 90% of electronic prescriptions, number of polymedicated users implemented. By definition it is assumed that total percentage of users with electronic prescription includes those users with more than 50% and 90% implementation of electronic records, and that those users with more than 90% implementation rates are consequently also included in the user group with implantation greater than 50%.

**Consumption:** number of total prescriptions (sum of prescriptions on paper and electronic format), number and % of electronic prescriptions, and total cost of medications dispensed. Total cost refers to the total cost of medications dispensed (the amount of reimbursement by the Catalan Health Service plus the out-of-pocket amount paid by patients). Drug use indicators were calculated from the following variables: number of prescriptions per polymedicated user (total and electronic format), total cost per polymedicated user and total cost per prescription.

**Literature review**

A systematic search was conducted (April 2014) through the PubMed database to identify the available evidence on electronic prescribing related to polypharmacy and health expenditure or cost analysis. The terms to run the search were located by the vocabulary Medical Subject Headings, with which the articles are indexed in the MEDLINE database. In order to complete this search and extend the results, additional searches combining free terms were also conducted. All search strategies (12) resulted in only 78 references. The studies identified through this search were evaluated by two independent reviewers to assess their inclusion in this document.

**Data processing and statistical analysis**

A database was designed. ANOVA and Student’s t-tests were used to determine the statistical significance ( $p<0.05$ ) of the differences using the SPSS version 20.0 statistics program. Regression testing was also performed in order to describe the tendency of the indicators relating to pharmaceutical services.

**RESULTS**

According to internal data in the Catalan Health Service and coinciding with published information,<sup>19</sup> the project achieved the implementation in 273 BHAs, representing 75% of the total territory in 2009. In December 2009, a cumulative total of 16 million electronic prescriptions dispensed were reached, adding more than 800,000 of the insured population and more than 5,000 health professionals (3,289 general practitioners and 2,497 pharmacists). Taking into account the progressive inclusion of primary care teams of BHR in the project during December 2009, the deployment of e-prescribing in primary care settings was considered complete (13% of patients who needed a prescription received an electronic one, 67.4% of which had more than 90% of their dispensed medications through e-prescribing). Therefore, electronic prescriptions could be dispensed throughout Catalonia.

In late 2009, 91% of primary care centers were prescribing electronically and the remaining 9% were under implementation of the tasks prior to incorporation, i.e adaptation of computer applications or training professionals.

During 2009, electronic prescription systems were implemented in 174 BHAs of BHR (82.1% of total BHAs in BHR). In total, 2,255,724 electronic prescriptions were billed, which accounted for 3% of total prescriptions billed. 494,628 users were



included (3% of total users with prescriptions in BHR). In the included BHAs, 1,810 general practitioners (47% of total in BHR) prescribed in electronic format, and 95.5% of community pharmacies in the territory dispensed prescriptions of this type.

Out of the 28 BHAs in BHR that implemented electronic prescribing in May 2009, only 6 reached the highest cumulative implementation grade during the period May-December 2009. This grade was higher than 25% so, over 25% of total prescriptions billed during the period May-December 2009 in each of these BHAs was electronic.

General details about the number of total insured users assigned to each of the 6 BHAs and the percentage of total electronic prescriptions during the period May-December 2009 are shown in Table 1. Data concerning e-prescription in polymedicated users in these BHAs are disclosed in Table 2.

In the 28 months study period, the 6 BHAs met a monthly average of  $169 \pm 31$  (min 89; max 238) polymedicated users. There was a significant upward trend in the number of polymedicated users, number of prescriptions and total cost ( $p < 0.05$ ), comparing the period January 2008-April 2009 with May 2009-April 2010. As depicted in online supplementary appendixes 1-3, the increase in those indicators seem independent from the implementation of electronic prescribing. Individually, 5 of the 6 BHAs showed this increase in those indicators, with the increase being significant in 4 of them ( $p < 0.05$ ). On the other hand, prescriptions per user, cost per user and cost per prescription showed a decrease between the pre and post implementation period, with cost per prescription ( $p < 0.05$ ) showing a significant decrease. The decrease in these 3 indicators was evident for both overall and 3 of the 6 BHAs individually, with results being significant in 2 of them ( $p < 0.05$ ). A slight upward trend is observed graphically in those 3 indicators prior to the implementation of electronic prescription; after this point the overall trend was decreasing (Figures 1-3).

## DISCUSSION

In order to explain the results from the study conducted, it should be noted that this is an exploratory, descriptive and transversal study about the implementation and deployment of electronic prescription in polymedicated users belonging to particular BHAs. The fact of studying pharmaceutical services in polymedicated users using new technologies as e-prescription may be important for health authorities because it could allow a step forward in the monitoring of the high costs that they entail and therefore manage

chronic care patients more properly.<sup>17 20</sup> Hence this study was designed to describe the tendency of some drug use indicators in the studied population.

It was still early to conduct a proper impact analysis of electronic prescription on all implemented users and population subgroups (by age, gender, pathology, polymedicated users), because it would be essential that total deployment of electronic prescription and subsequent penetration into the population were fulfilled.<sup>11 21</sup> The Catalan Health Service considered that the deployment of electronic prescription in the territory had finished in primary care setting at the time of study, but the truth is that all BHAs in Catalonia were not implemented. Impact studies could not be carried out until all BHAs were at least 80% implemented and had between six months and one year of experience with electronic prescription. In case of insured users, the implementation criterion could be considered as more than 90% of electronic prescriptions prescribed. In this sense, results derived from the measurement of indicators suggest previous approaches in our setting, and are essential to strengthen and guide any future evaluation of impact in primary care and in those areas where implementation is developing (specialty care, emergency departments, mental health centers and nursing homes).

There are currently no national published studies showing results in polymedicated populations as presented here. In the general population, some autonomous communities in Spain which have been operating with e-prescription (i.e. Andalusia, Balearic Islands, Community of Valencia, Galicia) have found that visits to professionals have been reduced by between 15% and 60% depending on the profile of the population being observed.<sup>11 22</sup> However, it is difficult to measure in economic terms the savings to the health system generated by a reduction in the number of visits as this cannot yet be quantified precisely. What has been determined, although there is controversy in the published results, is that in many of these communities the switch to electronic prescriptions coincided with an increase in health spending, as well as in number of prescriptions issued and total cost per user,<sup>23-25</sup> the latter differing from the results presented here (a decrease in cost per user between the pre and post implementation period was observed). The increase in drug expenditure may not always be significantly related to implantation of e-prescription, and could even be associated with the personal profile of users included in the e-prescription system and their health condition<sup>23</sup> (i.e. polymedicated users). Furthermore, specialized reports on public pharmaceutical expenditure issues show that the fluctuation in the number of

prescriptions always follows a seasonal pattern in Spain.<sup>26</sup> Throughout the year the number of prescriptions increases in January, June and October, mainly due to visits to physicians before (June) and after (January and October) the holiday period; this peak can also be observed for Easter holiday season (i.e. March 2008 and 2010; April 2009). In addition, during the study period, the increase in prescriptions every April was due to the annual review of the reference pricing system by the government, which reduces the price of drugs from year to year. The new prices came into effect in May and therefore the market share of these products and the turnover rate in pharmacies increased (and consequently the number of patients and billed prescriptions) in the previous month. In either case, it is important to highlight that all these monthly increases are merely transitory and they are irrelevant in the medium-long term evolution of time series, so they do not set a trend only by themselves.

Internationally, there are studies that describe quantitatively the influence of e-prescribing on implementation of pharmaceutical services and other elements of the health system. These results are mainly related to potential savings of e-prescribing (total cost of time taken by the practitioners, medical attendance, less equipment and operational costs).<sup>11-14 27</sup> However, there are none that assess drug use indicators in polymedicated users and therefore comparable to the results obtained in the present study.

Qualitative results were mostly observed in the 6 BHAs selected. Those results were inherent to the development of electronic prescription over the territories (i.e. increase in electronic prescribing and a decrease of the proportion of paper prescriptions). However, it is important to highlight some quantitatively different aspects have been significant since the introduction of electronic prescribing in the territory in May 2009. This includes the decrease in the number of prescriptions per user, total cost per user and total cost per prescription. In contrast, there was an increase in the number of prescriptions and the total cost, which could be attributed to the progressive deterioration of polymedicated users' health and the consequent need for more complex treatments such as the prescribing of therapeutic innovations, which are more expensive. In addition, duplication in the dispensation (due to coexistence of paper and electronic prescriptions in the same user) was also suggested as cause of that increase.<sup>28</sup> It is noteworthy that the results of any health intervention begin to appear at least one year after its start, and in this regard it would be necessary to assess the evolution over the years 2010 and 2011 to see whether there are more significant changes on any of the

measured indicators. Furthermore, it should be noted that from the experience gained so far in Catalonia from internal studies on this subject, it appears that not all changes produced on indicators of pharmaceutical services can be attributed to electronic prescriptions, whether these changes are positive or negative, because there have been several sources of variability that have hindered the formulation of hypotheses about its impact. The implementation of electronic prescribing was a dynamic process that followed different patterns depending on the time (different degree of implementation throughout the development, period of adaptation to the new tool), territory, providers (often there was variability between providers and even within the same provider), type of users (polymedicated/non polymedicated, by age group, etc), and healthcare professionals, among others, which will hinder future development of common profiles and design a model of this implementation globally.<sup>28 29</sup> However, there were other specific factors that more directly influenced one of the indicators analyzed: the case of the total cost (per user and per prescription), which could be affected by policies of rationalization of medication (generic prescribing, standardized protocols)<sup>30 31</sup> and changes in drug pricing (review of medication prices by the government), among others.

**CONCLUSIONS**

This study suggests that after the implementation of electronic prescribing (May 2009) in polymedicated users, the number of prescriptions per user, the total cost per user and the total cost per prescription decreased. Results indicate that there was an increase in the number of users, prescriptions and total cost; although graphically it was observed that the increase was independent from the implementation of electronic prescribing. It was suggested that the increase was probably due to the deterioration of the health of polymedicated users studied and duplication in the dispensation (due to coexistence of paper and electronic prescriptions in the same user).

Given the complexity and dynamism of the implementation of electronic prescription, there are several factors of variability, inherent or not to the deployment of the project, which can also influence the parameters related to pharmaceutical services (territory, time factor, providers, type of users, pricing policies and treatment protocols, among others). It is still too early to attribute all observed changes to electronic prescription because its integration into all elements of the health system was not fully completed at the time of study. However, the study provides a very valuable approach for future impact assessment.

**Contributors** IL-D collected the data, conducted the analysis and wrote the first draft of the manuscript. PM advised on design the study, data analysis and helped revise the draft of the manuscript. PL-C helped in conduct of study and data analysis. CFL helped data analysis and helped revise the draft of the manuscript. JLS contributed expertise in interpretation and analysis and helped revise the draft manuscript. AG-P contributed to design the study and expertise in interpretation and analysis. ELM contributed to the study design, contributed expertise in interpretation and analysis, and assisted in revising the draft manuscript. All authors reviewed and agreed on the submitted version of the manuscript.

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**Competing interests** None

**Data Sharing Statement:** No additional data available

REFERENCES

1. Government of Catalonia, Health Department. The electronic prescription (Rec@t). <http://www20.gencat.cat> (accessed 10 Jun 2014).

2. De La Puente ML, Fusté J. Health Map: a dynamic vision of health service planning in Catalonia, Spain. *Med Clin (Barc)* 2008; 131(Suppl 4):3-8.

3. Gilabert-Perramon A, López-Calahorra P, Escoda-Geli N, *et al.* Electronic prescription in Catalonia, Spain (Rec@t): a health tool. *Med Clin (Barc)* 2010;134(Suppl 1):49-55.

4. Decree 159/2007, of 24 July, which regulates electronic prescription and telematic processing of pharmaceutical services in charge of Catalan Health Service. DOGC num. 4934, of 26-07-2007, pp. 25.620-2. <http://www.gencat.cat> (accessed 10 Jun 2014)

5. Ammenwerth E, Schnell-Inderst P, Machan C, *et al.* The effect of electronic prescribing on medication errors and adverse drug events: a systematic review. *J Am Med Inform Assoc* 2008;15:585-600.

6. Van Doormaal JE, Van den Bemt P, Zaal RJ, *et al.* The influence that electronic prescribing has on medication errors and preventable adverse drug events: an interrupted time-series study. *J Am Med Inform Assoc* 2009;16:816-25.

7. Weingart SN, Massagli M, Cyrulik A, *et al.* Assessing the value of electronic prescribing in ambulatory care: A focus group study. *Int J Med Inform* 2009;78:571-8.

8. Lapane KL, Dubé C, Schneider KL, *et al.* Patient perceptions regarding electronic prescriptions: is the geriatric patient ready? *J Am Geriatr Soc* 2007; 55:1254-9.

9. Porteous T, Bond C, Robertson R, *et al.* Electronic transfer of prescription-related information: comparing views of patients, general practitioners, and pharmacists. *Br J Gen Pract* 2003;53:204-9.

10. Ministry of Health, Social Services and Equality. Project: Electronic prescription in the NHS. <http://www.msssi.gob.es> (accessed 10 Jun 2014).

11. European Commission, information society and media. Case studies. <http://www.ehr-impact.eu> (accessed 10 Jun 2014).

12. Government of Balearic Islands. Electronic prescription in Balearic Islands (Jan 2010). <http://www.recetaelectronicabaleares.es> (accessed 10 Jun 2014).

13. Cannaby S, Westcott D, Pedersen CD, *et al.* The cost benefit of electronic patient referrals in Denmark: summary report. *Stud Health Technol Inform* 2004;100:238-45.
14. National Prescribing Centre, NHS. Saving time, helping patients: A good practice guide to quality repeat prescribing (Jan 2004). <http://www.npci.org.uk> (accessed 10 Jun 2014).
15. European Patients Smart Open Services. Welcome to epSOS-a European eHealth Project. <http://www.epsos.eu> (accessed 10 Jun 2014).
16. Mäkinen M, Forsström J, Aärimaa M, *et al.* A European survey on the possibilities and obstacles of electronic prescriptions in cross-border healthcare. *Telemed J E Health* 2006;12:484-9.
17. Lizano-Díez I, Modamio P, López-Calahorra P, *et al.* Profile, cost and pattern of prescriptions for polymedicated patients in Catalonia, Spain. *BMJ Open* 2013;3:e003963.
18. Official statistics website of Catalonia (Idescat). Statistical yearbook of Catalonia. <http://www.idescat.cat> (accessed 10 Jun 2014).
19. Lizano I, Carbonell P, López P, *et al.* Impact of electronic prescription on users and the health system in Catalonia. *Gac Sanit* 2010; 24(Espec Congr 1):29.
20. World Health Organisation (WHO). Preventing chronic diseases, a vital investment. Department of Chronic Diseases and Health Promotion. Geneva, 2005. [http://www.who.int/chp/chronic\\_disease\\_report/en/](http://www.who.int/chp/chronic_disease_report/en/) (accessed 10 Jun 2014).
21. Hillestad R, Bigelow J, Bower A, *et al.* Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. *Health Aff (Millwood)* 2005;24:1103-17.
22. Suárez-Varela J, Beltrán C, Molina T, *et al.* Computer-aided prescribing: from utopia to reality. *Aten Primaria* 2005;35:451-9.
23. Mateu J, Boronat MA, Zaforteza M, *et al.* Electronic prescription: impact on pharmaceutical expenditure. *Gac Sanit* 2011;25(Espec Congr 1):7.
24. Calzón S, Mercader JJ, Montero JC, *et al.* Introduction of the electronic prescription in a primary care district: impact on pharmaceutical expenditure and the factors determining its use. *Aten Primaria* 2013;45:133-9.
25. Catalán-Arlandis, JL. The computerised prescription in Primary Care and its impact on drug spending using time series analysis. *Rev Calid Asist* 2011;26:18-27.



26. Farmaindustria. The pharmaceutical market in Spain. April 2009; Bulletin 48. <http://www.farmaindustria.es> (accessed 10 Jun 2014).

27. McMullin ST, Lonergan TP, Ryneerson CS. Twelve-month drug cost savings related to use of an electronic prescribing system with integrated decision support in primary care. *J Manag Care Pharm* 2005;11:322-32.

28. Acezat Oliva J. Impact of the use of ICT on pharmacy costs. The incorporation of the electronic prescription. *Aten Primaria* 2013;45:139-40.

29. Amirfar S, Anane S, Buck M, *et al.* Study of electronic prescribing rates and barriers identified among providers using electronic health records in New York City. *Inform Prim Care* 2011;19:91-7.

30. Crosson JC, Isaacson N, Lancaster D, *et al.* Variation in electronic prescribing implementation among twelve ambulatory practices. *J Gen Intern Med* 2008;23:364-71.

31. Fischer MA, Vogeli C, Stedman M, *et al.* Effect of electronic prescribing with formulary decision support on medication use and cost. *Arch Intern Med* 2008;168:2433-9.



Table 1 Detail on the number of total users, prescriptions and percentages in the 6 BHAs of study during the period May-December 2009.

BHAs of prescription	Total prescriptions	% Electronic prescriptions *	Total users	Users with electronic prescriptions <sup>†</sup>	% Users with electronic prescriptions <sup>‡</sup>	% Users with > 50% of electronic prescriptions <sup>‡</sup>	% Users > 90% of electronic prescriptions <sup>‡</sup>
BHA 1	438,228	42.03	107,306	35,000	32.62	28.55	21.03
BHA 2	293,860	37.69	55,776	20,593	36.92	32.75	24.74
BHA 3	329,073	33.81	72,484	24,100	33.25	29.55	23.41
BHA 4	191,705	32.96	43,731	14,346	32.81	28.32	21.97
BHA 5	351,972	29.57	72,585	23,274	32.06	28.18	22.10
BHA 6	264,308	25.06	53,511	13,142	24.56	21.08	15.14
<b>Total</b>	<b>1,869,146</b>	<b>34.20</b>	<b>405,393</b>	<b>130,455</b>	<b>32.20</b>	<b>28.20</b>	<b>21.50</b>

\* % Electronic prescriptions = (Total electronic prescriptions/Total prescriptions)\*100 = % Cumulative implantation grade (>25%)

<sup>†</sup> Users with electronic prescriptions: Users with, at least, one electronic prescription

<sup>‡</sup> % Users with electronic prescriptions = (Users with electronic prescriptions/Total users)\*100

Table 2 Detail on the number of polymedicated users, prescriptions and percentages in the 6 BHAs during the period May 2009-April 2010.

BHAs of prescription	Electronic prescriptions	Total prescriptions	% Electronic prescriptions *	Average number of prescriptions per polymedicated user	Average cost per polymedicated user	Average cost per prescription
BHA 1	11,708	18,243	64.18	24.75 ± 10.35	€ 345.52 ± 149.94	€ 13.86 ±0.83
BHA 2	7,497	12,149	61.71	27.20 ± 8.02	€ 407.54 ± 123.96	€ 14.95 ± 0.75
BHA 3	6,099	11,976	50.93	23.68 ± 9.40	€ 369.10 ± 156.87	€ 15.55 ± 1.52
BHA 4	1,995	4,026	49.55	24.75 ± 11.60	€ 396.02 ± 186.81	€ 16.39 ± 2.36
BHA 5	3,796	10,133	37.46	25.09 ± 8.57	€ 412.70 ± 156.66	€ 16.39 ± 2.00
BHA 6	1,322	5,425	24.37	31.15 ± 3.16	€ 438.50 ± 48.96	€ 14.08 ± 0.80
Total	32,417	61,952	52.33	25.01 ± 9.42	€ 376.68 ± 143.32	€ 15.05 ± 0.44

\* % Electronic prescriptions = (Total electronic prescriptions/Total prescriptions)\*100

## FIGURES

Figure 1 Evolution of number of prescriptions per polymedicated user in the 6 BHAs of study

Figure 2 Evolution of total cost per polymedicated user in the 6 BHAs of study

Figure 3 Evolution of total cost per prescription in polymedicated users in the 6 BHAs of study

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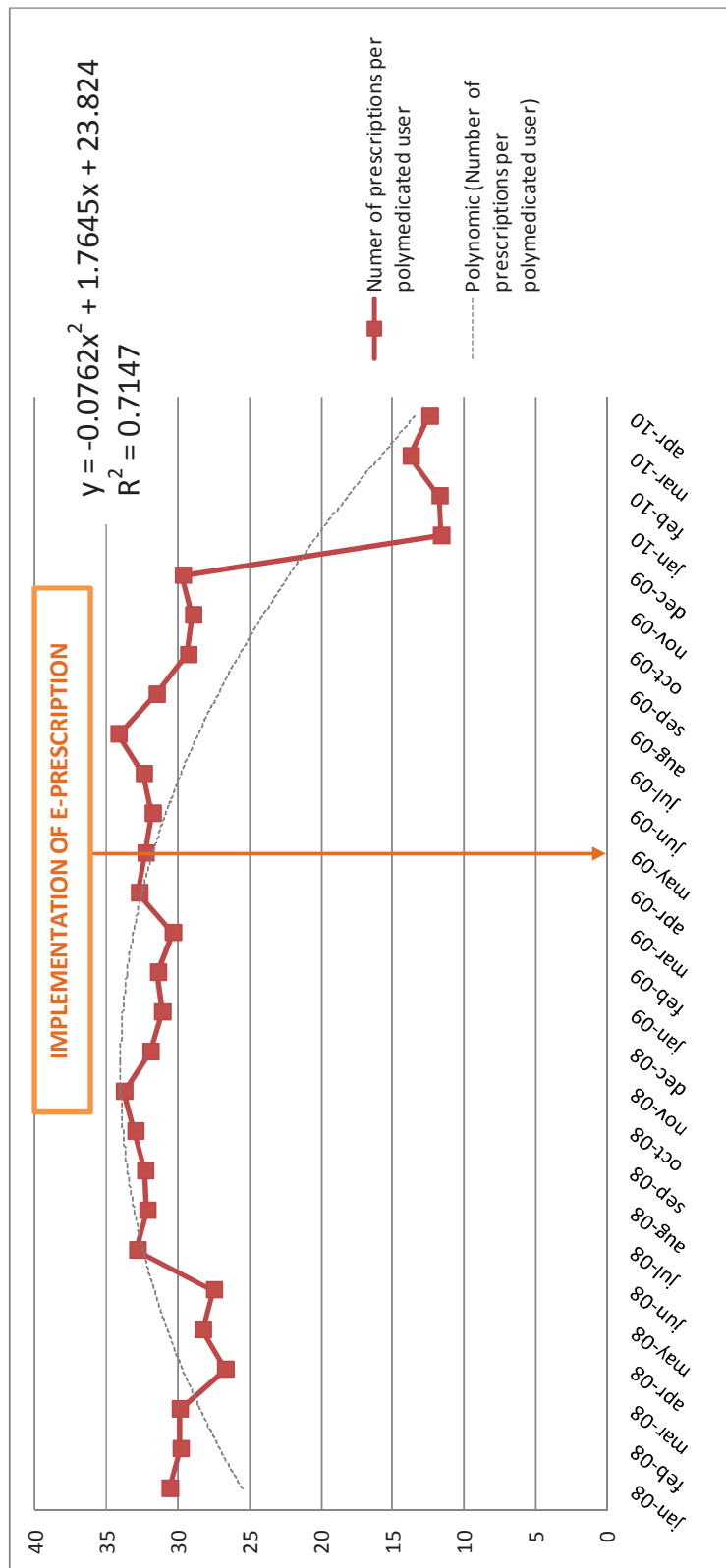
**Online Supplementary appendices**

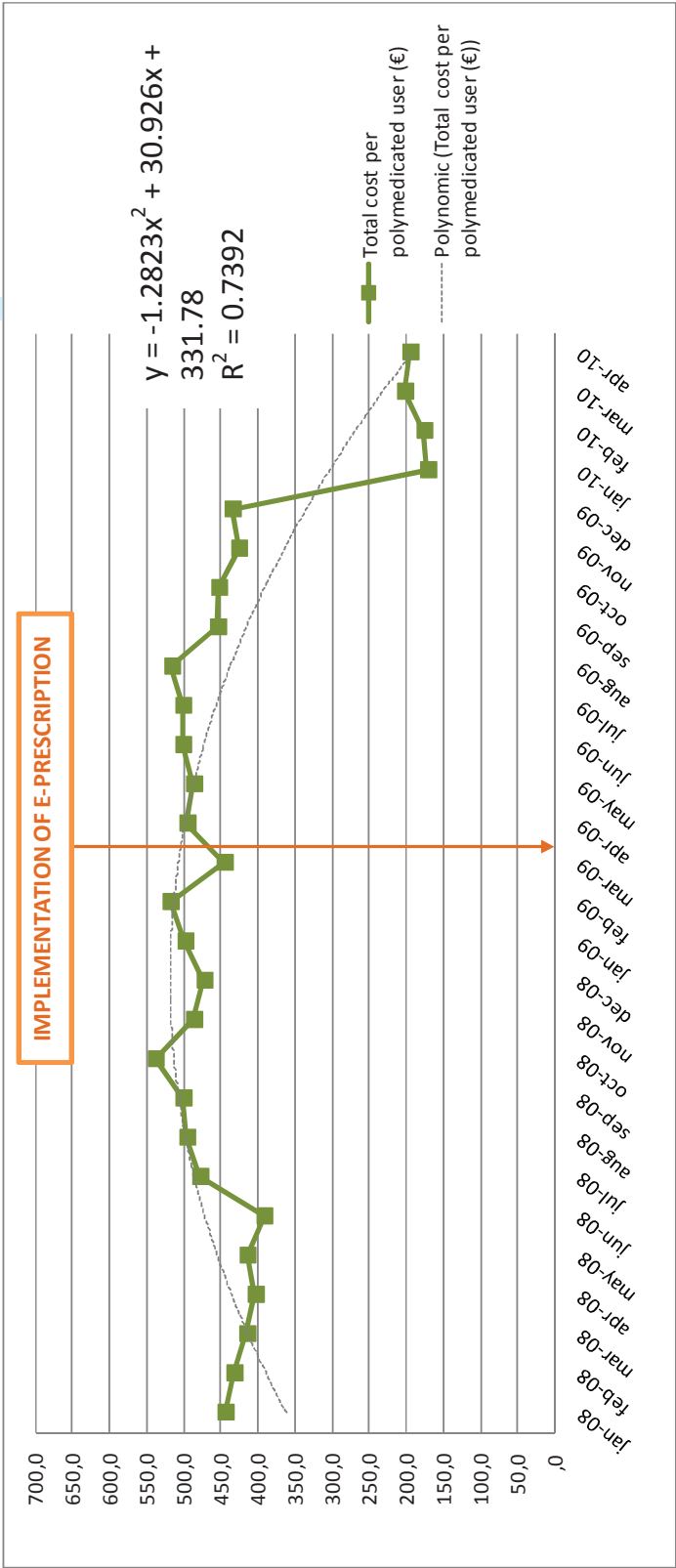
Appendix 1 Evolution of growth in number of polymedicated users in the 6 BHAs of study

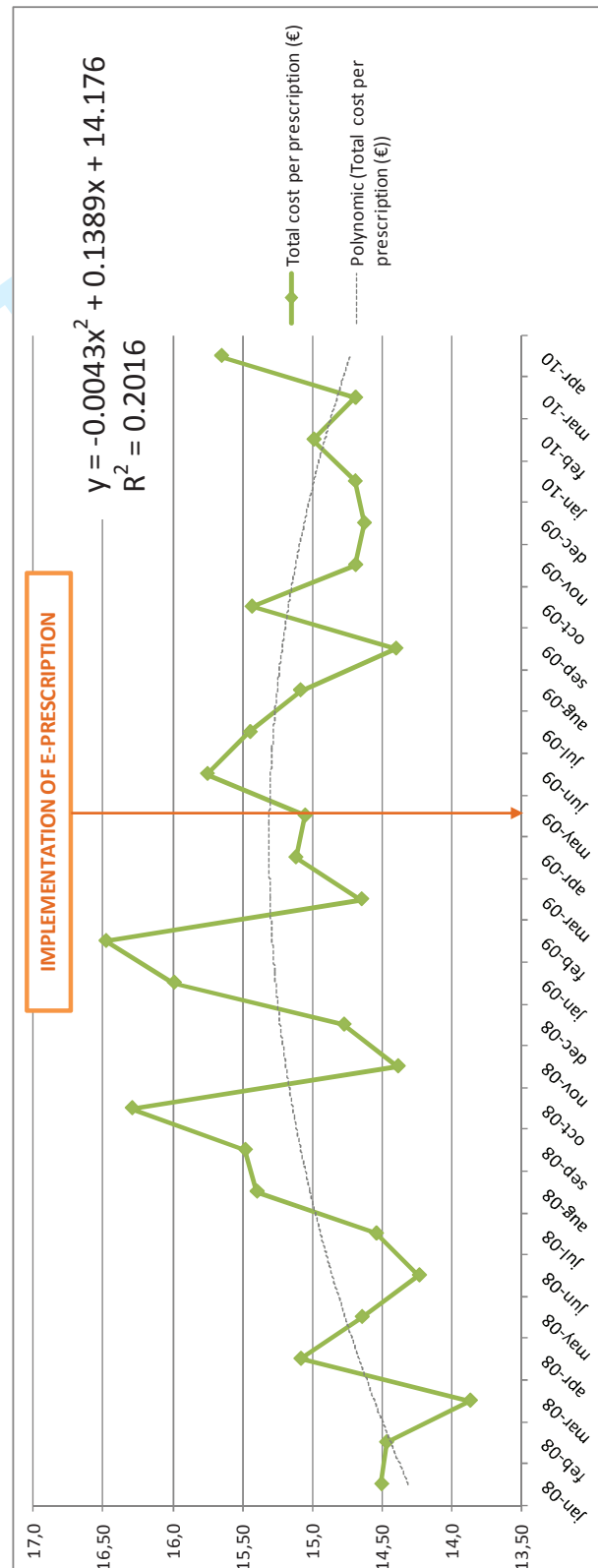
Appendix 2 Evolution of number of prescriptions in polymedicated users in the 6 BHAs of study

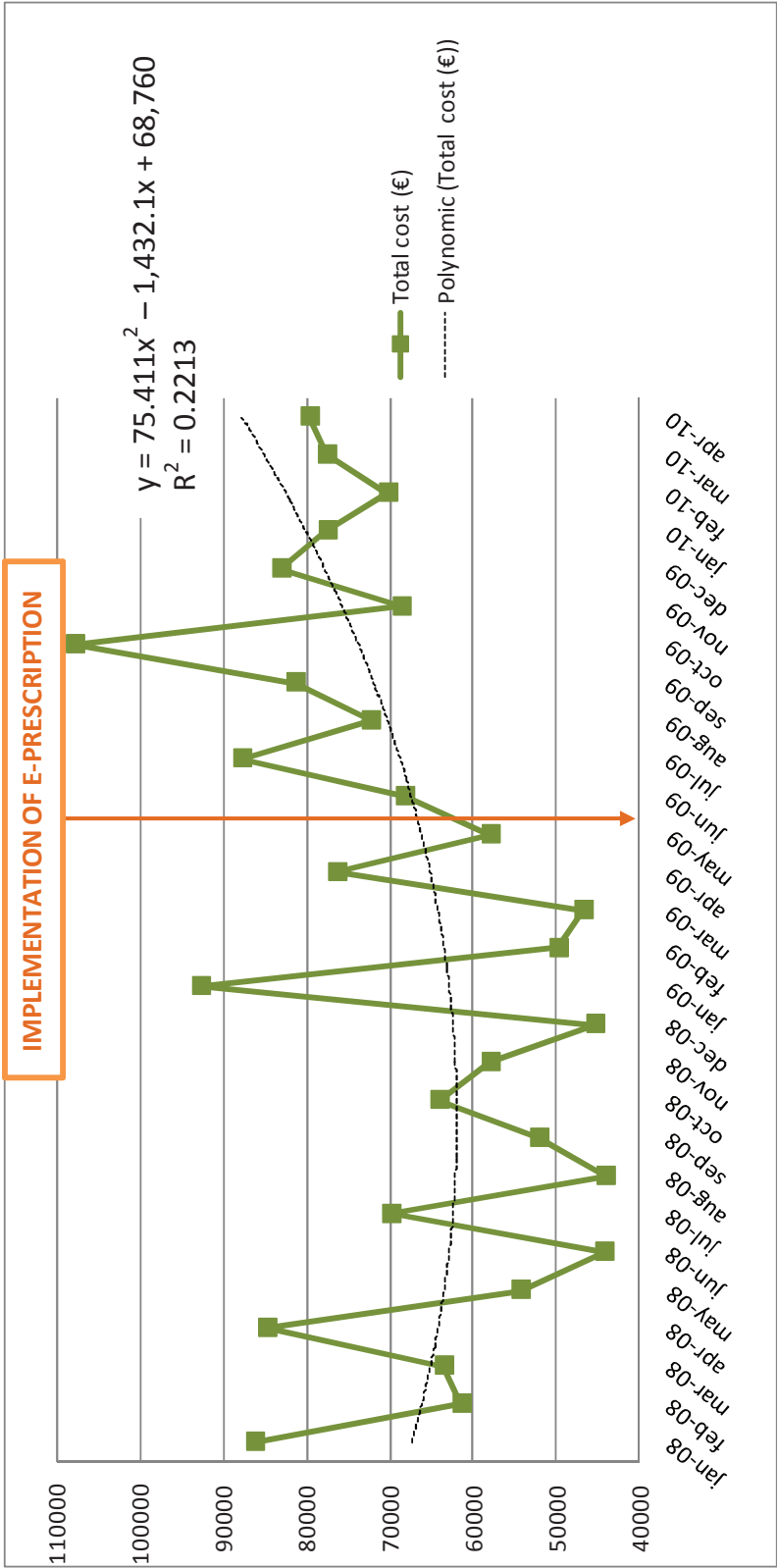
Appendix 3 Evolution of growth in total cost in polymedicated users in the 6 BHAs of study

For peer review only

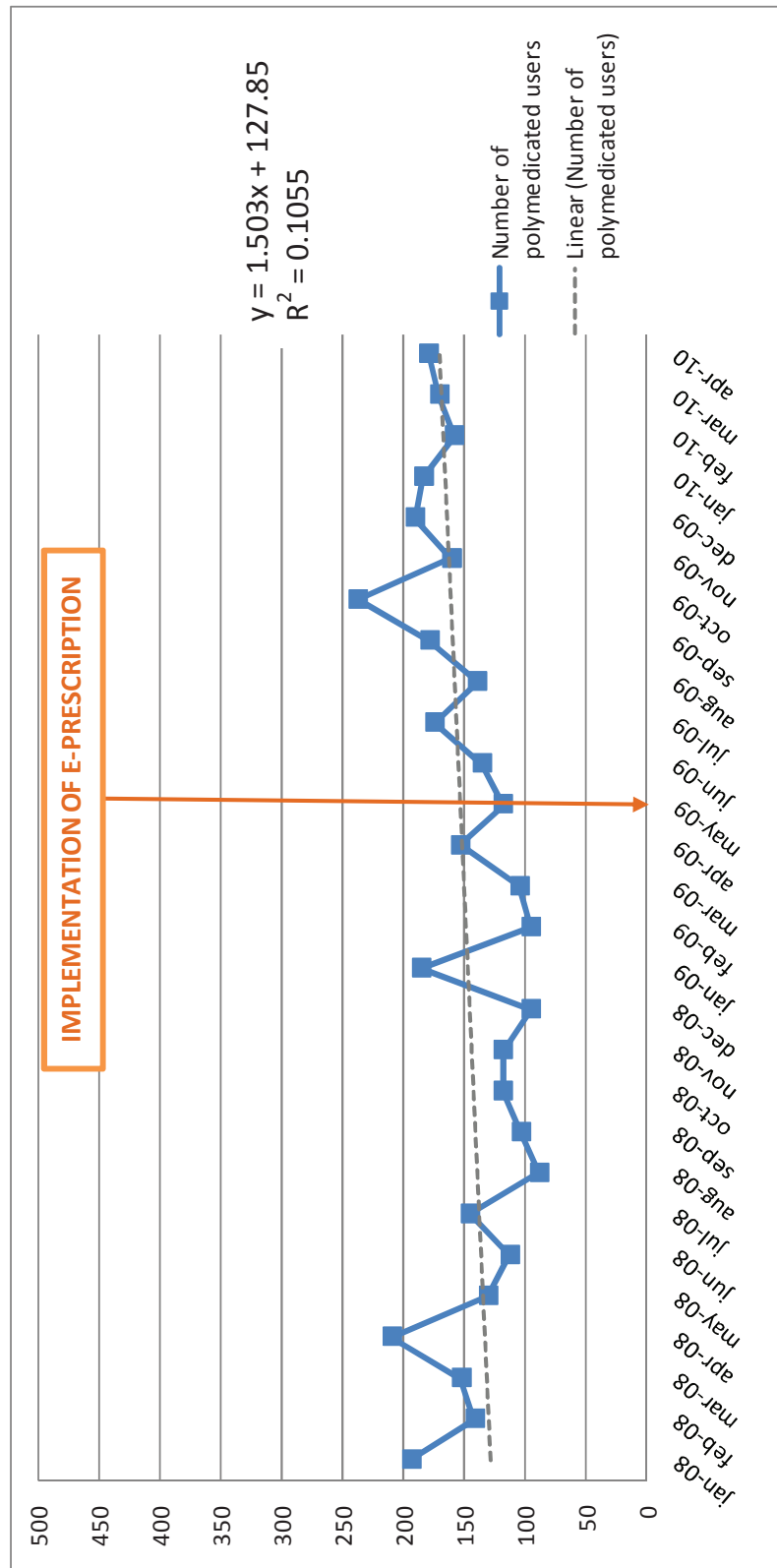


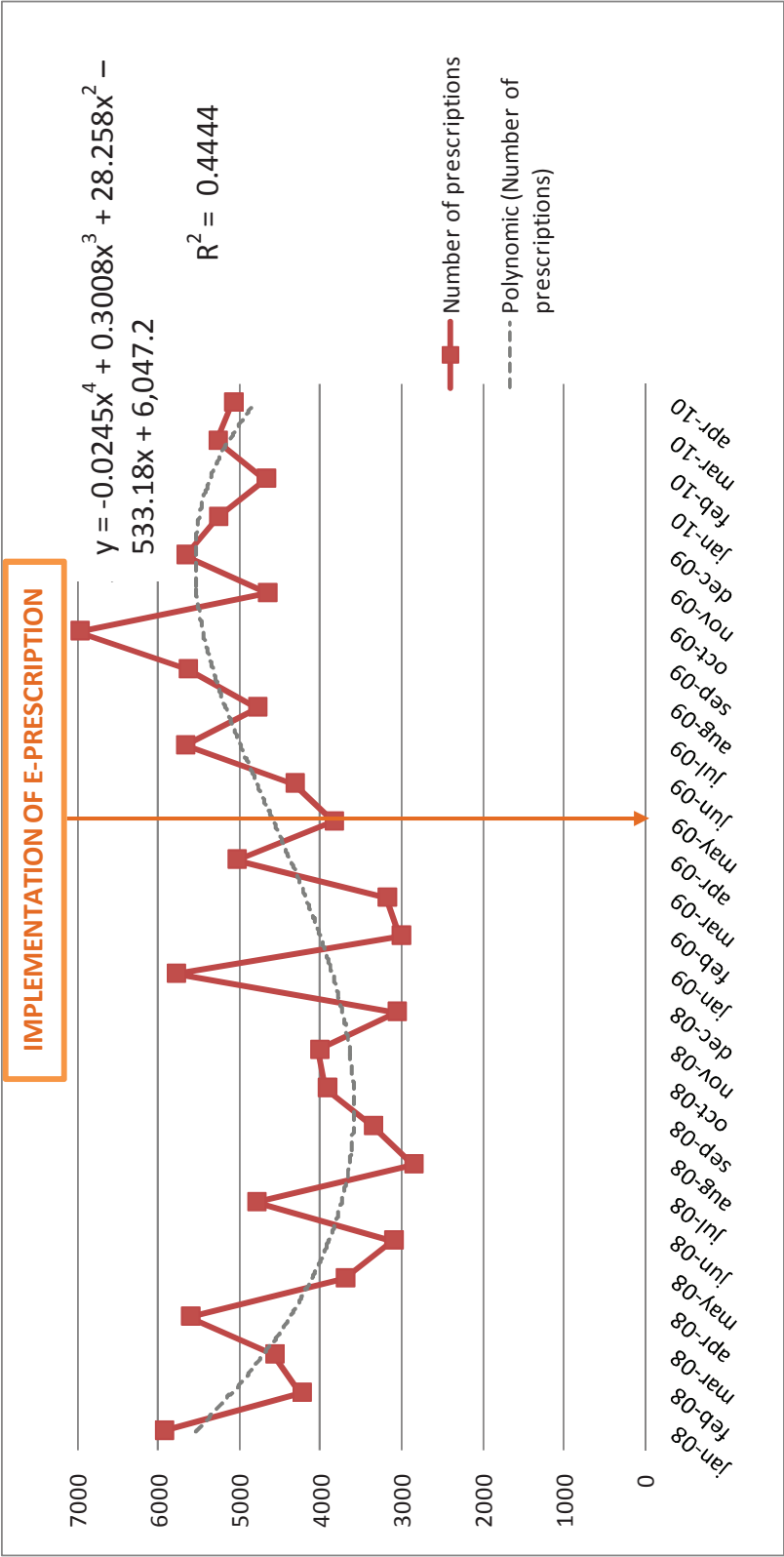












# BMJ Open

## Evaluation of electronic prescription implementation in polymedicated users of Catalonia, Spain: a population-based longitudinal study

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Manuscripts

**Evaluation of electronic prescription implementation in polymedicated users of Catalonia, Spain: a population-based longitudinal study**

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**Keywords:** electronic prescribing, polymedication, primary health care, drug use indicators

**Word count:** 3,232

## ABSTRACT

**Objectives:** To assess whether electronic prescribing is a comprehensive health management tool that may contribute to rational drug use, particularly in polymedicated patients receiving sixteen or more medications in the public healthcare system in the Barcelona Health Region (BHR).

**Design:** 16 months of retrospective study followed by 12 months of prospective monitoring.

**Setting:** Primary healthcare in BHR, Catalonia, Spain.

**Participants:** All insured patients, especially those who are polymedicated in 6 Basic Health Areas (BHA). Polymedicated patients were those with a consumption of  $\geq 16$  drugs/month.

**Interventions:** Monitoring demographic and consumption variables obtained from the records of prescriptions dispensed in pharmacies and charged to the public health system, as well as the resulting drug use indicators. Territorial variables related to implementation of electronic prescribing were also described and were obtained from the institutional data related to the deployment of the project.

**Main outcome measures:** Trend in drug use indicators (number of prescriptions per polymedicated user, total cost per polymedicated user and total cost per prescription) according to e-prescription implementation.

**Results:** There was a significant upward trend in the number of polymedicated users, number of prescriptions and total cost ( $p < 0.05$ ), which seemed independent from the implementation of electronic prescribing when comparing the pre and post implementation period. Prescriptions per user and cost per user showed a decrease between the pre and post implementation period, being significant in 2 BHA ( $p < 0.05$ ).

**Conclusions:** Results suggest that after the implementation of electronic prescribing, drug use indicators decreased in polymedicated patients. In addition, this study provides a very valuable approach for future impact assessment.

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**Strengths and limitations of this study**

- This is a novel study that describes the implementation of an e-prescribing system in polymedicated users. It establishes many drug use indicators (demographic and consumption variables) and represents a very important step towards an integral and integrated pharmaceutical management in health services.
- An economic impact study could not be carried out because it was still too early to attribute all observed changes to electronic prescriptions because its integration into all elements of the health system was not fully completed at the time of study.
- This is the first report showing results of drug use indicators in polymedicated patients with e-prescriptions. It provides a very valuable approach for future impact assessment.

## INTRODUCTION

Rec@t is the electronic prescription system in the autonomous region of Catalonia (north-eastern Spain).<sup>1</sup> The Catalan Health Service has played an active part leading the development of the project, as guarantor of public health services that purchases and evaluates healthcare depending on the needs of the population.

Rec@t is a strategic healthcare project that aims to provide advantages concerning quality, accessibility, safety, efficiency, continuity of care, and rational drug use.<sup>2</sup> The implementation of this system is a comprehensive health management tool that addresses the entire process involved in pharmaceutical services. This includes everything, from prescribing and dispensing in community pharmacies to the assessment and payment of the benefit.<sup>3</sup>

It entails a different healthcare model than it had thus far, highlighting in particular the elimination of paper-based prescribing. The key element that helps serve this task is the medication plan,<sup>1</sup> which is the printed sheet that is given to patients and contains all the information necessary to be able to follow the treatment correctly (i.e. dose and frequency of administration). It facilitates the feedback between prescribers and dispensers, forming a new communication channel between them and helping to prevent medication errors and duplicities of treatment.<sup>2-6</sup> Therefore, electronic prescribing is an important tool to control chronic patients, the elderly and polymedicated users, who generate the greatest interest because of their therapeutic complexity, high drug consumption and total cost for the healthcare system.<sup>7-8</sup>

Rec@t implementation began in 2007 after an initial pilot experience in 2006 that proved the feasibility of the designed system. The progressive extension of electronic prescriptions started, reaching 100% of the equipment in late 2010.<sup>2</sup> Currently, it is considered fully complete in primary care, and in specialty care it has reached significant levels on the extent and volume of prescriptions issued and dispensed (98.33% of prescriptions were electronic in May 2014), so it is expected to be completed this year.<sup>9</sup> Community pharmacies completely work with electronic prescribing, given that more than 90% of prescriptions dispensed are already in electronic format. More than 12,500 physicians who have joined the system so far have made prescriptions to more than 5 million patients, reaching more than 275 million medications dispensed.<sup>10</sup>

Regarding other Spanish autonomous regions, similar projects in electronic prescribing were already underway in primary care at the same time as Catalonia. The most advanced of which were in Andalusia (southern Spain),<sup>10</sup> and in Balearic Islands (eastern Spain).<sup>11</sup> At an international level, it is noteworthy to mention experiences in Denmark,<sup>12</sup> Sweden,<sup>10</sup> and England,<sup>10 13</sup> where healthcare organizations are involved in improving quality of prescriptions through e-prescribing systems along with Spain.<sup>9</sup> The ultimate goal of these experiences is to be brought into a single overall system allowing interoperability in the near future, both nationally and throughout Europe.<sup>9 14 15</sup>

From an international point of view, even though the electronic prescribing system involves a change of paradigm that will enable a better assessment of drug use, there is a lack of evidence reported in the literature in terms of health outcomes evaluation.

The aim of our study was to assess whether electronic prescribing may contribute to rational drug use, particularly in polymedicated patients receiving sixteen or more medications in the public healthcare system in the Barcelona Health Region (BHR). These results will be useful to get prior information for future impact assessment of this technology on risk population.

**METHOD**

**Design and setting of the study**

Longitudinal study in a primary care setting, conducted on the general population and polymedicated patients in those Basic Health Areas (BHAs) in BHR with the greatest cumulative grade of implementation in e-prescription between May and December of 2009. Monitoring included 16 months of retrospective study (January 2008-April 2009) and 12 months of prospective follow-up from the beginning of the implementation of Rec@t in BHR (May 2009) to April 2010. This was considered a sufficiently large analysis for the objectives to be achieved (28 months).

The Catalan healthcare model is decentralised, to better know the health needs of the population and develop a better relationship with providers in each health region and their respective BHAs. BHAs are the basic territorial units around which primary healthcare services are organised (areas or municipalities), according to the population's access to the services and the efficiency in organising health resources.<sup>1,16</sup> In terms of prescriptions billing, during the period 2008-2010, the average of total prescriptions per year in Catalonia was 143,753,915 ± 4,500,218 (99,786,576 ± 1,251,654 in BHR). According to the average yearly number of prescriptions per capita and cost per



prescription, both indicators were similar in Catalonia and BHR:  $18.98 \pm 0.50$  vs.  $18.94 \pm 0.78$  and  $13.24 \pm 0.18$  vs.  $13.25 \pm 0.19$  respectively.<sup>17</sup>

A polymedicated user in the present study was defined as someone receiving 16 or more active principles in a month, according to the Efficiency Indicators in Primary Care that are periodically evaluated by an internal Management Committee in the Catalan Health Service (macromanagement level).<sup>18</sup>

### Data source

The study used population data from 2008, 2009 and 2010 Catalonia censuses.<sup>17</sup> Records of billed prescriptions were also utilized, based on both paper and electronic prescriptions that were dispensed in community pharmacies and charged to the Catalan Health Service. This information was obtained by means of the personal healthcare card, the document that provides citizens with access to the centres, services and benefits of the public health system (these services include drugs subsidised by the Catalan Health Service).<sup>1</sup> This information is stored monthly in a computer system, which allows the design and gathering of information required for the management and monitoring of pharmaceutical services.

Prescriptions in paper format are usually issued for 3 months ("chronic patients program" in primary care setting) and electronic prescriptions are usually issued for 12 months (maximum); at least once a year patients visit the doctor to renew them.

Polymedicated users were selected monthly, so polymedicated population varied throughout the whole study (28 months, which involved 28 data analysis). Due to the fact that each user had its own identification code, given by the personal healthcare card, subsequent analyses could be carried out so as to determine monthly duplicities of users.

### Ethical statement

Ethics approval was not required to undertake this study. The study was unfunded.

### Variables of the study

The variables used to analyze the implementation of e-prescription were as follows.

Territorial: number and % of BHAs implemented, % of primary care centres implemented, grade of implementation, number of general practitioners (e-prescription prescribers), % of general practitioners implemented, number of community pharmacies

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which dispensed electronic prescriptions and % of community pharmacies implemented. Grade of implementation is the percentage of electronic prescribing on the total number of prescriptions billed (sum of prescriptions on paper and electronic format) for a given month or a specific time period (cumulative implementation grade). Depending on the variable described, the grade of implementation is indicative of the deployment of electronic prescription in the territory (i.e. in a given BHA) or the percentage of electronic prescriptions prescribed to an individual in a given period. Demographic: number and % of users implemented, % of users with more than 50% of electronic prescriptions and % of users with more than 90% of electronic prescriptions, number of polymedicated users implemented. By definition it is assumed that total percentage of users with electronic prescription includes those users with more than 50% and 90% implementation of electronic records, and that those users with more than 90% implementation rates are consequently also included in the user group with implementation greater than 50%.

Consumption: number of total prescriptions (sum of prescriptions on paper and electronic format), number and % of electronic prescriptions, and total cost of medications dispensed. Total cost refers to the total cost of medications dispensed (the amount of reimbursement by the Catalan Health Service plus the out-of-pocket amount paid by patients). Drug use indicators were calculated from the following variables: number of prescriptions per polymedicated user (total and electronic format), total cost per polymedicated user and total cost per prescription.

**Literature review**

A systematic search was conducted (April 2014) through the PubMed database to identify the available evidence on electronic prescribing related to polypharmacy and health expenditure or cost analysis. The terms to run the search were located by the vocabulary Medical Subject Headings, with which the articles are indexed in the MEDLINE database. In order to complete this search and extend the results, additional searches combining free terms were also conducted. All search strategies (12) resulted in only 78 references. The studies identified through this search were evaluated by two independent reviewers to assess their inclusion in this document.

## Data processing and statistical analysis

A database was designed. ANOVA and Student's t-tests were used to determine the statistical significance ( $p < 0.05$ ) of the differences using the SPSS version 20.0 statistics program. Regression testing was also performed in order to describe the tendency of the indicators relating to pharmaceutical services.

## RESULTS

### General population

According to internal data in the Catalan Health Service and coinciding with published information,<sup>19</sup> the project achieved the implementation in 273 BHAs, representing 75% of the total territory in 2009. In December 2009, a cumulative total of 16 million electronic prescriptions dispensed were reached, adding more than 800,000 of the insured population and more than 5,000 health professionals (3,289 general practitioners and 2,497 pharmacists). Taking into account the progressive inclusion of primary care teams of BHR in the project during December 2009, the deployment of e-prescribing in primary care settings was considered complete (13% of patients who needed a prescription received an electronic one, 67.4% of which had more than 90% of their dispensed medications through e-prescribing). Therefore, electronic prescriptions could be dispensed throughout Catalonia.

In late 2009, 91% of primary care centers were prescribing electronically and the remaining 9% were under implementation of the tasks prior to incorporation, i.e adaptation of computer applications or training professionals.

During 2009, electronic prescription systems were implemented in 174 BHAs of BHR (82.1% of total BHAs in BHR). In total, 2,255,724 electronic prescriptions were billed, which accounted for 3% of total prescriptions billed. 494,628 users were included (3% of total users with prescriptions in BHR). In the included BHAs, 1,810 general practitioners (47% of total in BHR) prescribed in electronic format, and 95.5% of community pharmacies in the territory dispensed prescriptions of this type.

Out of the 28 BHAs in BHR that implemented electronic prescribing in May 2009, only 6 reached the highest cumulative implementation grade ( $> 25\%$ ) during the period May-December 2009.

General details about the number of total insured users assigned to each of the 6 BHAs and the percentage of total electronic prescriptions during the period May-December 2009 are shown in Table 1.

**Polymedicated users**

Data concerning e-prescription in polymedicated users in these BHAs are disclosed in Table 2. In the 28 months study period, the 6 BHAs met a monthly average of  $169 \pm 31$  (min 89; max 238) polymedicated users. 1,575 polymedicated users were analyzed; 54.4% of them were only polymedicated in 1 month of the study and 4% of them had that condition in  $\geq 10$  months; there were no users being polymedicated during  $> 20$  months.

There was a significant upward trend in the number of polymedicated users, number of prescriptions and total cost ( $p<0.05$ ), comparing the period January 2008-April 2009 with May 2009-April 2010. As depicted in online supplementary appendixes 1-3, the increase in those indicators seem independent from the implementation of electronic prescribing. Individually, 5 of the 6 BHAs showed this increase in those indicators, with the increase being significant in 4 of them ( $p<0.05$ ). On the other hand, prescriptions per user and cost per user showed a decrease between the pre and post implementation period, whereas cost per prescription showed no variation. The decrease in prescription per user and cost per used was evident for both overall and 3 of the 6 BHAs individually, with results being significant in 2 of them ( $p<0.05$ ). A slight upward trend is observed graphically in those 2 indicators prior to the implementation of electronic prescription; after this point the overall trend was decreasing (Figures 1-3).

**DISCUSSION**

In order to explain the results from the study conducted, it should be noted that this is an exploratory and longitudinal study about the implementation and deployment of electronic prescription in polymedicated users belonging to particular BHAs. The fact of studying pharmaceutical services in polymedicated users using new technologies as e-prescription may be important for health authorities because it could allow a step forward in the monitoring of the high costs that they entail and therefore manage chronic care patients more properly.<sup>18 20</sup> Hence this study was designed to describe the tendency of some drug use indicators in the studied population.

It was still early to conduct a proper impact analysis of electronic prescription on all implemented users and population subgroups (by age, gender, pathology, polymedicated users), because it would be essential that total deployment of electronic prescription and subsequent penetration into the population were fulfilled.<sup>10 21</sup> The

Catalan Health Service considered that the deployment of electronic prescription in the territory had finished in primary care setting at the time of study, but the truth is that all BHAs in Catalonia were not implemented. Impact studies could not be carried out until all BHAs were at least 80% implemented and had between six months and one year of experience with electronic prescription. In case of insured users, the implementation criterion could be considered as more than 90% of electronic prescriptions prescribed. In this sense, results derived from the measurement of indicators suggest previous approaches in our setting, and are essential to strengthen and guide any future evaluation of impact in primary care and in those areas where implementation is developing (specialty care, emergency departments, mental health centers and nursing homes).

There are currently no national published studies showing results in polymedicated populations as presented here. In the general population, some autonomous communities in Spain which have been operating with e-prescription (i.e. Andalusia, Balearic Islands, Community of Valencia, Galicia) have found that visits to professionals have been reduced by between 15% and 60% depending on the profile of the population being observed.<sup>10 22</sup> However, it is difficult to measure in economic terms the savings to the health system generated by a reduction in the number of visits as this cannot yet be quantified precisely. What has been determined, although there is controversy in the published results, is that in many of these communities the switch to electronic prescriptions coincided with an increase in health spending, as well as in number of prescriptions issued and total cost per user,<sup>23-25</sup> the latter differing from the results presented here (a decrease in cost per user between the pre and post implementation period was observed). The increase in drug expenditure may not always be significantly related to implementation of e-prescription, and could even be associated with the personal profile of users included in the e-prescription system and their health condition<sup>23</sup> (i.e. polymedicated users). Furthermore, specialized reports on public pharmaceutical expenditure issues show that the fluctuation in the number of prescriptions always follows a seasonal pattern in Spain.<sup>26</sup> Throughout the year the number of prescriptions increases in January, June and October, mainly due to visits to physicians before (June) and after (January and October) the holiday period; this peak can also be observed for Easter holiday season (i.e. March 2008 and 2010; April 2009). In addition, during the study period, the increase in prescriptions every April was due to the annual review of the reference pricing system by the government, which reduces the

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price of drugs from year to year. The new prices came into effect in May and therefore the market share of these products and the turnover rate in pharmacies increased (and consequently the number of patients and billed prescriptions) in the previous month. In either case, it is important to highlight that all these monthly increases are merely transitory and they are irrelevant in the medium-long term evolution of time series, so they do not set a trend only by themselves.

Internationally, there are studies that describe quantitatively the influence of e-prescribing on implementation of pharmaceutical services and other elements of the health system. These results are mainly related to potential savings of e-prescribing (total cost of time taken by the practitioners, medical attendance, less equipment and operational costs).<sup>10-13 27</sup> However, there are none that assess drug use indicators in polymedicated users and therefore comparable to the results obtained in the present study.

Qualitative results were mostly observed in the 6 BHAs selected. Those results were inherent to the development of electronic prescription over the territories (i.e. increase in electronic prescribing and a decrease of the proportion of paper prescriptions). However, it is important to highlight some quantitatively different aspects have been significant since the introduction of electronic prescribing in the territory in May 2009. This includes the decrease in the number of prescriptions per user, and total cost per user. In contrast, there was an increase in the number of prescriptions and the total cost, which could be attributed to the progressive deterioration of polymedicated users' health and the consequent need for more complex treatments such as the prescribing of therapeutic innovations, which are more expensive. In addition, duplication in the dispensation (due to coexistence of paper and electronic prescriptions in the same user) was also suggested as cause of that increase.<sup>28</sup> It is noteworthy that the results of any health intervention begin to appear at least one year after its start, and in this regard it would be necessary to assess the evolution over the years 2010 and 2011 to see whether there are more significant changes on any of the measured indicators. The implementation of electronic prescribing was a dynamic process that followed different patterns depending on the time (different degree of implementation throughout the development, period of adaptation to the new tool), territory, providers (often there was variability between providers and even within the same provider), type of users (polymedicated/non polymedicated, by age group, etc.), and healthcare professionals, among others, which will hinder future development of common profiles and design a

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3 model of this implementation globally.<sup>28 29</sup> However, there were other specific factors  
4 that more directly influenced one of the indicators analyzed: the case of the total cost  
5 (per user and per prescription), which could be affected by policies of rationalization of  
6 medication (generic prescribing, standardized protocols)<sup>30 31</sup> and changes in drug pricing  
7 (review of medication prices by the government), among others.  
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### 11 12 13 **Study limitation**

14 This is an exploratory, longitudinal study and may have an inherent bias common to this  
15 type of study. Furthermore, the period covered is short to establish causal relationships  
16 between e-prescribing and variations in drug use indicators. However, it gives hints of  
17 some trends that are essential to conduct future impact assessment studies and it could  
18 also provide evidence on this topic. This study was carried out in 6 BHAs because at the  
19 time of study they were those BHAs with the greatest implementation grade.  
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### 26 27 **CONCLUSIONS**

28 After the implementation of electronic prescribing (May 2009) in polymedicated users,  
29 the number of prescriptions per user, and the total cost per user decreased. This study  
30 provides a very valuable approach for future impact assessment.  
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33 The electronic prescribing system allows the closest follow-up of drug use indicators  
34 in each stage (i.e number of prescriptions issued vs. dispensed), so health professionals  
35 can control risk patients in terms of rational drug use, improving quality of services and  
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**Contributors** IL-D collected the data, conducted the analysis and wrote the first draft of the manuscript. PM advised on design the study, data analysis and helped revise the draft of the manuscript. PL-C helped in conduct of study and data analysis. CFL helped data analysis and helped revise the draft of the manuscript. JLS contributed expertise in interpretation and analysis and helped revise the draft manuscript. AG-P contributed to design the study and expertise in interpretation and analysis. ELM contributed to the study design, contributed expertise in interpretation and analysis, and assisted in revising the draft manuscript. All authors reviewed and agreed on the submitted version of the manuscript.

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**Competing interests** None

**Data Sharing Statement:** No additional data available

**FIGURE ANS SUPP LEGENDS:**  
**FIGURES**

Figure 1 Evolution of number of prescriptions per polymedicated user in the 6 BHAs of study

Figure 2 Evolution of total cost per polymedicated user in the 6 BHAs of study

Figure 3 Evolution of total cost per prescription in polymedicated users in the 6 BHAs of study



## Online Supplementary appendices

Appendix 1 Evolution of growth in number of polymedicated users in the 6 BHAs of study

Appendix 2 Evolution of number of prescriptions in polymedicated users in the 6 BHAs of study

Appendix 3 Evolution of growth in total cost in polymedicated users in the 6 BHAs of study

REFERENCES

1. Government of Catalonia, Health Department. The electronic prescription (Rec@t). <http://www20.gencat.cat> (accessed 10 Jun 2014).

2. Gilabert-Perramon A, López-Calahorra P, Escoda-Geli N, *et al.* Electronic prescription in Catalonia, Spain (Rec@t): a health tool. *Med Clin (Barc)* 2010;134(Suppl 1):49-55.

3. Decree 159/2007, of 24 July, which regulates electronic prescription and telematic processing of pharmaceutical services in charge of Catalan Health Service. DOGC num. 4934, of 26-07-2007, pp. 25.620-2. <http://www.gencat.cat> (accessed 10 Jun 2014)

4. Ammenwerth E, Schnell-Inderst P, Machan C, *et al.* The effect of electronic prescribing on medication errors and adverse drug events: a systematic review. *J Am Med Inform Assoc* 2008;15:585-600.

5. Van Doormaal JE, Van den Bemt P, Zaal RJ, *et al.* The influence that electronic prescribing has on medication errors and preventable adverse drug events: an interrupted time-series study. *J Am Med Inform Assoc* 2009;16:816-25.

6. Weingart SN, Massagli M, Cyrulik A, *et al.* Assessing the value of electronic prescribing in ambulatory care: A focus group study. *Int J Med Inform* 2009;78:571-8.

7. Lapane KL, Dubé C, Schneider KL, *et al.* Patient perceptions regarding electronic prescriptions: is the geriatric patient ready? *J Am Geriatr Soc* 2007; 55:1254-9.

8. Porteous T, Bond C, Robertson R, *et al.* Electronic transfer of prescription-related information: comparing views of patients, general practitioners, and pharmacists. *Br J Gen Pract* 2003;53:204-9.

9. Ministry of Health, Social Services and Equality. Project: Electronic prescription in the NHS (June 2014). <http://www.msssi.gob.es> (accessed 10 Jun 2014).

10. European Commission, information society and media. Case studies. <http://www.ehr-impact.eu> (accessed 10 Jun 2014).

11. Government of Balearic Islands. Electronic prescription in Balearic Islands (Jan 2010). <http://www.recetaelectronicabaleares.es> (accessed 10 Jun 2014).

12. Cannaby S, Westcott D, Pedersen CD, *et al.* The cost benefit of electronic patient referrals in Denmark: summary report. *Stud Health Technol Inform* 2004;100:238-45.

13. National Prescribing Centre, NHS. Saving time, helping patients: A good practice guide to quality repeat prescribing (Jan 2004). <http://www.npci.org.uk> (accessed 10 Jun 2014).
14. European Patients Smart Open Services. Welcome to epSOS-a European eHealth Project. <http://www.epsos.eu> (accessed 10 Jun 2014).
15. Mäkinen M, Forsström J, Äärimala M, *et al.* A European survey on the possibilities and obstacles of electronic prescriptions in cross-border healthcare. *Telemed J E Health* 2006;12:484-9.
16. De La Puente ML, Fusté J. Health Map: a dynamic vision of health service planning in Catalonia, Spain. *Med Clin (Barc)* 2008; 131(Suppl 4):3-8.
17. Official statistics website of Catalonia (Idescat). Statistical yearbook of Catalonia. <http://www.idescat.cat> (accessed 10 Jun 2014).
18. Lizano-Díez I, Modamio P, López-Calahorra P, *et al.* Profile, cost and pattern of prescriptions for polymedicated patients in Catalonia, Spain. *BMJ Open* 2013;3:e003963.
19. Lizano I, Carbonell P, López P, *et al.* Impact of electronic prescription on users and the health system in Catalonia. *Gac Sanit* 2010; 24(Espec Congr 1):29.
20. World Health Organisation (WHO). Preventing chronic diseases, a vital investment. Department of Chronic Diseases and Health Promotion. Geneva, 2005. [http://www.who.int/chp/chronic\\_disease\\_report/en/](http://www.who.int/chp/chronic_disease_report/en/) (accessed 10 Jun 2014).
21. Hillestad R, Bigelow J, Bower A, *et al.* Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. *Health Aff (Millwood)* 2005;24:1103-17.
22. Suárez-Varela J, Beltrán C, Molina T, *et al.* Computer-aided prescribing: from utopia to reality. *Aten Primaria* 2005;35:451-9.
23. Mateu J, Boronat MA, Zaforteza M, *et al.* Electronic prescription: impact on pharmaceutical expenditure. *Gac Sanit* 2011;25(Espec Congr 1):7.
24. Calzón S, Mercader JJ, Montero JC, *et al.* Introduction of the electronic prescription in a primary care district: impact on pharmaceutical expenditure and the factors determining its use. *Aten Primaria* 2013;45:133-9.
25. Catalán-Arlandis, JL. The computerised prescription in Primary Care and its impact on drug spending using time series analysis. *Rev Calid Asist* 2011;26:18-27.
26. Farmaindustria. The pharmaceutical market in Spain. April 2009; Bulletin 48. <http://www.farmaindustria.es> (accessed 10 Jun 2014).

27. McMullin ST, Lonergan TP, Ryneerson CS. Twelve-month drug cost savings related to use of an electronic prescribing system with integrated decision support in primary care. *J Manag Care Pharm* 2005;11:322-32.

28. Acezat Oliva J. Impact of the use of ICT on pharmacy costs. The incorporation of the electronic prescription. *Aten Primaria* 2013;45:139-40.

29. Amirfar S, Anane S, Buck M, *et al.* Study of electronic prescribing rates and barriers identified among providers using electronic health records in New York City. *Inform Prim Care* 2011;19:91-7.

30. Crosson JC, Isaacson N, Lancaster D, *et al.* Variation in electronic prescribing implementation among twelve ambulatory practices. *J Gen Intern Med* 2008;23:364-71.

31. Fischer MA, Vogeli C, Stedman M, *et al.* Effect of electronic prescribing with formulary decision support on medication use and cost. *Arch Intern Med* 2008;168:2433-9.

Table 1 Detail on the number of total users, prescriptions and percentages in the 6 BHAs of study during the period May-December 2009.

BHAs of prescription	Total users	Total prescriptions	Average number of prescriptions per user	% Electronic prescriptions <sup>*</sup>	Users with electronic prescriptions <sup>†</sup>	% Users with electronic prescriptions <sup>‡</sup>	% Users with > 50% of electronic prescriptions <sup>‡</sup>	% Users > 90% of electronic prescriptions <sup>‡</sup>
BHA 1	107,306	438,228	4.08	42,03%	35,000	32.62%	28.55%	21.03%
BHA 2	55,776	293,860	5.27	37,69%	20,593	36.92%	32.75%	24.74%
BHA 3	72,484	329,073	4.54	33,81%	24,100	33.25%	29.55%	23.41%
BHA 4	43,731	191,705	4.38	32,96%	14,346	32.81%	28.32%	21.97%
BHA 5	72,585	351,972	4.85	29,57%	23,274	32.06%	28.18%	22.10%
BHA 6	53,511	264,308	4.94	25,06%	13,142	24.56%	21.08%	15.14%
<b>Total</b>	<b>405,393</b>	<b>1,869,146</b>	<b>4.61</b>	<b>34.20%</b>	<b>130,455</b>	<b>32.20%</b>	<b>28.20%</b>	<b>21.50%</b>

\* % Electronic prescriptions = (Total electronic prescriptions/Total prescriptions)\*100 = % Cumulative implementation grade (>25%)

† Users with electronic prescriptions: Users with, at least, one electronic prescription

‡ % Users with electronic prescriptions = (Users with electronic prescriptions/Total users)\*100

Results were calculated from global cumulative data in each BHA

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Table 2 Detail on the number of polymedicated users, prescriptions and related drug use indicators in the 6 BHAs during the post-implementation period May 2009-April 2010.

BHAs of prescription	Polymedicated users	Electronic prescriptions	Total prescriptions	% Electronic prescriptions *	Average number of prescriptions per polymedicated user	Average cost per polymedicated user	Average cost per prescription
BHA 1	241	11,708	18,243	64.18%	30.71 ± 3.01	€ 404.02 ± 48.25	€ 13.28 ± 1.89
BHA 2	112	7,497	12,149	61.71%	31.44 ± 1.97	€ 455.69 ± 48.80	€ 14. 52 ± 1.53
BHA 3	297	6,099	11,976	50.93%	29.65 ± 2.82	€ 467.32 ± 70.36	€ 15.73 ± 1.38
BHA 4	275	1,995	4,026	49.55%	30.57 ± 3.83	€ 500.14 ± 88.99	€ 16.41 ± 2.34
BHA 5	284	3,796	10,133	37.46%	30.70 ± 1.56	€ 503.95 ± 70.23	€ 16.41 ± 2.02
BHA 6	366	1,322	5,554	23.80%	32 ± 3.36	€ 450.74 ± 50.30	€ 14.10 ± 0.79
<b>Total</b>	<b>1,575</b>	<b>32,417</b>	<b>62,081</b>	<b>52.22%</b>	<b>30.73 ± 1.96</b>	<b>€ 454.03 ± 35.22</b>	<b>€ 14.79 ± 0.98</b>

\* % Electronic prescriptions = (Total electronic prescriptions/Total prescriptions)\*100

Averages of monthly global data in the 6 BHAs were calculated for prescriptions/user, cost/user and cost/prescription

All data included made reference to the whole prospective follow-up period (average data resulting from 12 months, post-implementation period

For peer review only

**Evaluation of electronic prescription implementation in polymedicated users of Catalonia, Spain: a population-based longitudinal study**

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**Word count:** 3,232



## ABSTRACT

**Objectives:** To assess whether electronic prescribing is a comprehensive health management tool that may contribute to rational drug use, particularly in polymedicated patients receiving sixteen or more medications in the public healthcare system in the Barcelona Health Region (BHR).

**Design:** 16 months of retrospective study followed by 12 months of prospective monitoring.

**Setting:** Primary healthcare in BHR, Catalonia, Spain.

**Participants:** All insured patients, especially those who are polymedicated in 6 Basic Health Areas (BHA). Polymedicated patients were those with a consumption of  $\geq 16$  drugs/month.

**Interventions:** Monitoring demographic and consumption variables obtained from the records of prescriptions dispensed in pharmacies and charged to the public health system, as well as the resulting drug use indicators. Territorial variables related to implementation of electronic prescribing were also described and were obtained from the institutional data related to the deployment of the project.

**Main outcome measures:** Trend in drug use indicators (number of prescriptions per polymedicated user, total cost per polymedicated user and total cost per prescription) according to e-prescription implementation.

**Results:** There was a significant upward trend in the number of polymedicated users, number of prescriptions and total cost ( $p < 0.05$ ), which seemed independent from the implementation of electronic prescribing when comparing the pre and post implementation period. Prescriptions per user and cost per user showed a decrease between the pre and post implementation period, being significant in 2 BHAs ( $p < 0.05$ ).

**Conclusions:** Results suggest that after the implementation of electronic prescribing, drug use indicators decreased in polymedicated patients. In addition, this study provides a very valuable approach for future impact assessment.

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**Strengths and limitations of this study**

- This is a novel study that describes the implementation of an e-prescribing system in polymedicated users. It establishes many drug use indicators (demographic and consumption variables) and represents a very important step towards an integral and integrated pharmaceutical management in health services.
- An economic impact study could not be carried out because it was still too early to attribute all observed changes to electronic prescriptions because its integration into all elements of the health system was not fully completed at the time of study.
- This is the first report showing results of drug use indicators in polymedicated patients with e-prescriptions. It provides a very valuable approach for future impact assessment.

## INTRODUCTION

Rec@t is the electronic prescription system in the autonomous region of Catalonia (north-eastern Spain).<sup>1</sup> The Catalan Health Service has played an active part leading the development of the project, as guarantor of public health services that purchases and evaluates healthcare depending on the needs of the population.

Rec@t is a strategic healthcare project that aims to provide advantages concerning quality, accessibility, safety, efficiency, continuity of care, and rational drug use.<sup>2</sup> The implementation of this system is a comprehensive health management tool that addresses the entire process involved in pharmaceutical services. This includes everything, from prescribing and dispensing in community pharmacies to the assessment and payment of the benefit.<sup>3</sup>

It entails a different healthcare model than it had thus far, highlighting in particular the elimination of paper-based prescribing. The key element that helps serve this task is the medication plan,<sup>1</sup> which is the printed sheet that is given to patients and contains all the information necessary to be able to follow the treatment correctly (i.e. dose and frequency of administration). It facilitates the feedback between prescribers and dispensers, forming a new communication channel between them and helping to prevent medication errors and duplicities of treatment.<sup>2 4-6</sup> Therefore, electronic prescribing is an important tool to control chronic patients, the elderly and polymedicated users, who generate the greatest interest because of their therapeutic complexity, high drug consumption and total cost for the healthcare system.<sup>7 8</sup>

Rec@t implementation began in 2007 after an initial pilot experience in 2006 that proved the feasibility of the designed system. The progressive extension of electronic prescriptions started, reaching 100% of the equipment in late 2010.<sup>2</sup> Currently, it is considered fully complete in primary care, and in specialty care it has reached significant levels on the extent and volume of prescriptions issued and dispensed (98.33% of prescriptions were electronic in May 2014), so it is expected to be completed this year.<sup>9</sup> Community pharmacies completely work with electronic prescribing, given that more than 90% of prescriptions dispensed are already in electronic format. More than 12,500 physicians who have joined the system so far have made prescriptions to more than 5 million patients, reaching more than 275 million medications dispensed.<sup>1 9</sup>

Regarding other Spanish autonomous regions, similar projects in electronic prescribing were already underway in primary care at the same time as Catalonia. The most advanced of which were in Andalusia (southern Spain),<sup>10</sup> and in Balearic Islands (eastern Spain).<sup>11</sup> At an international level, it is noteworthy to mention experiences in Denmark,<sup>12</sup> Sweden,<sup>10</sup> and England,<sup>10 13</sup> where healthcare organizations are involved in improving quality of prescriptions through e-prescribing systems along with Spain.<sup>9</sup> The ultimate goal of these experiences is to be brought into a single overall system allowing interoperability in the near future, both nationally and throughout Europe.<sup>9 14 15</sup>

From an international point of view, even though the electronic prescribing system involves a change of paradigm that will enable a better assessment of drug use, there is a lack of evidence reported in the literature in terms of health outcomes evaluation.

The aim of our study was to assess whether electronic prescribing may contribute to rational drug use, particularly in polymedicated patients receiving sixteen or more medications in the public healthcare system in the Barcelona Health Region (BHR). These results will be useful to get prior information for future impact assessment of this technology on risk population.

METHOD

Design and setting of the study

Longitudinal study in a primary care setting, conducted on the general population and polymedicated patients in those Basic Health Areas (BHAs) in BHR with the greatest cumulative grade of implementation in e-prescription between May and December of 2009. Monitoring included 16 months of retrospective study (January 2008-April 2009) and 12 months of prospective follow-up from the beginning of the implementation of Rec@t in BHR (May 2009) to April 2010. This was considered a sufficiently large analysis for the objectives to be achieved (28 months).

The Catalan healthcare model is decentralised, to better know the health needs of the population and develop a better relationship with providers in each health region and their respective BHAs. BHAs are the basic territorial units around which primary healthcare services are organised (areas or municipalities), according to the population's access to the services and the efficiency in organising health resources.<sup>1,16</sup> In terms of prescriptions billing, during the period 2008-2010, the average of total prescriptions per year in Catalonia was 143,753,915 ± 4,500,218 (99,786,576 ± 1,251,654 in BHR). According to the average yearly number of prescriptions per capita and cost per

prescription, both indicators were similar in Catalonia and BHR:  $18.98 \pm 0.50$  vs.  $18.94 \pm 0.78$  and  $13.24 \pm 0.18$  vs.  $13.25 \pm 0.19$  respectively.<sup>17</sup>

A polymedicated user in the present study was defined as someone receiving 16 or more active principles in a month, according to the Efficiency Indicators in Primary Care that are periodically evaluated by an internal Management Committee in the Catalan Health Service (macromanagement level).<sup>18</sup>

### Data source

The study used population data from 2008, 2009 and 2010 Catalonia censuses.<sup>17</sup> Records of billed prescriptions were also utilized, based on both paper and electronic prescriptions that were dispensed in community pharmacies and charged to the Catalan Health Service. This information was obtained by means of the personal healthcare card, the document that provides citizens with access to the centres, services and benefits of the public health system (these services include drugs subsidised by the Catalan Health Service).<sup>1</sup> This information is stored monthly in a computer system, which allows the design and gathering of information required for the management and monitoring of pharmaceutical services.

Prescriptions in paper format are usually issued for 3 months ("chronic patients program" in primary care setting) and electronic prescriptions are usually issued for 12 months (maximum); at least once a year patients visit the doctor to renew them.

Polymedicated users were selected monthly, so polymedicated population varied throughout the whole study (28 months, which involved 28 data analysis). Due to the fact that each user had its own identification code, given by the personal healthcare card, subsequent analyses could be carried out so as to determine monthly duplicities of users.

### Ethical statement

Ethics approval was not required to undertake this study. The study was unfunded.

### Variables of the study

The variables used to analyze the implementation of e-prescription were as follows.

Territorial: number and % of BHAs implemented, % of primary care centres implemented, grade of implementation, number of general practitioners (e-prescription prescribers), % of general practitioners implemented, number of community pharmacies

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which dispensed electronic prescriptions and % of community pharmacies implemented. Grade of implementation is the percentage of electronic prescribing on the total number of prescriptions billed (sum of prescriptions on paper and electronic format) for a given month or a specific time period (cumulative implementation grade). Depending on the variable described, the grade of implementation is indicative of the deployment of electronic prescription in the territory (i.e. in a given BHA) or the percentage of electronic prescriptions prescribed to an individual in a given period. Demographic: number and % of users implemented, % of users with more than 50% of electronic prescriptions and % of users with more than 90% of electronic prescriptions, number of polymedicated users implemented. By definition it is assumed that total percentage of users with electronic prescription includes those users with more than 50% and 90% implementation of electronic records, and that those users with more than 90% implementation rates are consequently also included in the user group with **implementation** greater than 50%.

Consumption: number of total prescriptions (sum of prescriptions on paper and electronic format), number and % of electronic prescriptions, and total cost of medications dispensed. Total cost refers to the total cost of medications dispensed (the amount of reimbursement by the Catalan Health Service plus the out-of-pocket amount paid by patients). Drug use indicators were calculated from the following variables: number of prescriptions per polymedicated user (total and electronic format), total cost per polymedicated user and total cost per prescription.

**Literature review**

A systematic search was conducted (April 2014) through the PubMed database to identify the available evidence on electronic prescribing related to polypharmacy and health expenditure or cost analysis. The terms to run the search were located by the vocabulary Medical Subject Headings, with which the articles are indexed in the MEDLINE database. In order to complete this search and extend the results, additional searches combining free terms were also conducted. All search strategies (12) resulted in only 78 references. The studies identified through this search were evaluated by two independent reviewers to assess their inclusion in this document.

## Data processing and statistical analysis

A database was designed. ANOVA and Student's t-tests were used to determine the statistical significance ( $p < 0.05$ ) of the differences using the SPSS version 20.0 statistics program. Regression testing was also performed in order to describe the tendency of the indicators relating to pharmaceutical services.

## RESULTS

### General population

According to internal data in the Catalan Health Service and coinciding with published information,<sup>19</sup> the project achieved the implementation in 273 BHAs, representing 75% of the total territory in 2009. In December 2009, a cumulative total of 16 million electronic prescriptions dispensed were reached, adding more than 800,000 of the insured population and more than 5,000 health professionals (3,289 general practitioners and 2,497 pharmacists). Taking into account the progressive inclusion of primary care teams of BHR in the project during December 2009, the deployment of e-prescribing in primary care settings was considered complete (13% of patients who needed a prescription received an electronic one, 67.4% of which had more than 90% of their dispensed medications through e-prescribing). Therefore, electronic prescriptions could be dispensed throughout Catalonia.

In late 2009, 91% of primary care centers were prescribing electronically and the remaining 9% were under implementation of the tasks prior to incorporation, i.e adaptation of computer applications or training professionals.

During 2009, electronic prescription systems were implemented in 174 BHAs of BHR (82.1% of total BHAs in BHR). In total, 2,255,724 electronic prescriptions were billed, which accounted for 3% of total prescriptions billed. 494,628 users were included (3% of total users with prescriptions in BHR). In the included BHAs, 1,810 general practitioners (47% of total in BHR) prescribed in electronic format, and 95.5% of community pharmacies in the territory dispensed prescriptions of this type.

Out of the 28 BHAs in BHR that implemented electronic prescribing in May 2009, only 6 reached the highest cumulative implementation grade ( $> 25\%$ ) during the period May-December 2009. ~~This grade was higher than 25% so, over 25% of total prescriptions billed during the period May-December 2009 in each of these BHAs was electronic.~~



General details about the number of total insured users assigned to each of the 6 BHAs and the percentage of total electronic prescriptions during the period May-December 2009 are shown in Table 1.

**Polymedicated users**

Data concerning e-prescription in polymedicated users in these BHAs are disclosed in Table 2. In the 28 months study period, the 6 BHAs met a monthly average of  $169 \pm 31$  (min 89; max 238) polymedicated users. 1,575 polymedicated users were analyzed; 54.4% of them were only polymedicated in 1 month of the study and 4% of them had that condition in  $\geq 10$  months; there were no users being polymedicated during  $> 20$  months.

There was a significant upward trend in the number of polymedicated users, number of prescriptions and total cost ( $p<0.05$ ), comparing the period January 2008-April 2009 with May 2009-April 2010. As depicted in online supplementary appendixes 1-3, the increase in those indicators seem independent from the implementation of electronic prescribing. Individually, 5 of the 6 BHAs showed this increase in those indicators, with the increase being significant in 4 of them ( $p<0.05$ ). On the other hand, prescriptions per user and cost per user and cost per prescription showed a decrease between the pre and post implementation period, whereas cost per prescription ( $p<0.05$ ) showed no variation. The decrease in prescription per user and cost per used was evident for both overall and 3 of the 6 BHAs individually, with results being significant in 2 of them ( $p<0.05$ ). A slight upward trend is observed graphically in those 2 indicators prior to the implementation of electronic prescription; after this point the overall trend was decreasing (Figures 1-3).

**DISCUSSION**

In order to explain the results from the study conducted, it should be noted that this is an exploratory, ~~descriptive~~—and longitudinal study about the implementation and deployment of electronic prescription in polymedicated users belonging to particular BHAs. The fact of studying pharmaceutical services in polymedicated users using new technologies as e-prescription may be important for health authorities because it could allow a step forward in the monitoring of the high costs that they entail and therefore



manage chronic care patients more properly.<sup>18 20</sup> Hence this study was designed to describe the tendency of some drug use indicators in the studied population.

It was still early to conduct a proper impact analysis of electronic prescription on all implemented users and population subgroups (by age, gender, pathology, polymedicated users), because it would be essential that total deployment of electronic prescription and subsequent penetration into the population were fulfilled.<sup>10 21</sup> The Catalan Health Service considered that the deployment of electronic prescription in the territory had finished in primary care setting at the time of study, but the truth is that all BHAs in Catalonia were not implemented. Impact studies could not be carried out until all BHAs were at least 80% implemented and had between six months and one year of experience with electronic prescription. In case of insured users, the implementation criterion could be considered as more than 90% of electronic prescriptions prescribed. In this sense, results derived from the measurement of indicators suggest previous approaches in our setting, and are essential to strengthen and guide any future evaluation of impact in primary care and in those areas where implementation is developing (specialty care, emergency departments, mental health centers and nursing homes).

There are currently no national published studies showing results in polymedicated populations as presented here. In the general population, some autonomous communities in Spain which have been operating with e-prescription (i.e. Andalusia, Balearic Islands, Community of Valencia, Galicia) have found that visits to professionals have been reduced by between 15% and 60% depending on the profile of the population being observed.<sup>10 22</sup> However, it is difficult to measure in economic terms the savings to the health system generated by a reduction in the number of visits as this cannot yet be quantified precisely. What has been determined, although there is controversy in the published results, is that in many of these communities the switch to electronic prescriptions coincided with an increase in health spending, as well as in number of prescriptions issued and total cost per user,<sup>23-25</sup> the latter differing from the results presented here (a decrease in cost per user between the pre and post implementation period was observed). The increase in drug expenditure may not always be significantly related to **implementation** of e-prescription, and could even be associated with the personal profile of users included in the e-prescription system and their health condition<sup>23</sup> (i.e. polymedicated users). Furthermore, specialized reports on public pharmaceutical expenditure issues show that the fluctuation in the number of

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prescriptions always follows a seasonal pattern in Spain.<sup>26</sup> Throughout the year the number of prescriptions increases in January, June and October, mainly due to visits to physicians before (June) and after (January and October) the holiday period; this peak can also be observed for Easter holiday season (i.e. March 2008 and 2010; April 2009). In addition, during the study period, the increase in prescriptions every April was due to the annual review of the reference pricing system by the government, which reduces the price of drugs from year to year. The new prices came into effect in May and therefore the market share of these products and the turnover rate in pharmacies increased (and consequently the number of patients and billed prescriptions) in the previous month. In either case, it is important to highlight that all these monthly increases are merely transitory and they are irrelevant in the medium-long term evolution of time series, so they do not set a trend only by themselves.

Internationally, there are studies that describe quantitatively the influence of e-prescribing on implementation of pharmaceutical services and other elements of the health system. These results are mainly related to potential savings of e-prescribing (total cost of time taken by the practitioners, medical attendance, less equipment and operational costs).<sup>10-13 27</sup> However, there are none that assess drug use indicators in polymedicated users and therefore comparable to the results obtained in the present study.

Qualitative results were mostly observed in the 6 BHAs selected. Those results were inherent to the development of electronic prescription over the territories (i.e. increase in electronic prescribing and a decrease of the proportion of paper prescriptions). However, it is important to highlight some quantitatively different aspects have been significant since the introduction of electronic prescribing in the territory in May 2009. This includes the decrease in the number of prescriptions per user, ~~and total cost per user and total cost per prescription~~. In contrast, there was an increase in the number of prescriptions and the total cost, which could be attributed to the progressive deterioration of polymedicated users' health and the consequent need for more complex treatments such as the prescribing of therapeutic innovations, which are more expensive. In addition, duplication in the dispensation (due to coexistence of paper and electronic prescriptions in the same user) was also suggested as cause of that increase.<sup>28</sup> It is noteworthy that the results of any health intervention begin to appear at least one year after its start, and in this regard it would be necessary to assess the evolution over the years 2010 and 2011 to see whether there are more significant changes on any of the

measured indicators. Furthermore, it should be noted that from the experience gained so far in Catalonia from internal studies on this subject, it appears that not all changes produced on indicators of pharmaceutical services can be attributed to electronic prescriptions, whether these changes are positive or negative, because there have been several sources of variability that have hindered the formulation of hypotheses about its impact. The implementation of electronic prescribing was a dynamic process that followed different patterns depending on the time (different degree of implementation throughout the development, period of adaptation to the new tool), territory, providers (often there was variability between providers and even within the same provider), type of users (polymedicated/non polymedicated, by age group, etc), and healthcare professionals, among others, which will hinder future development of common profiles and design a model of this implementation globally.<sup>28 29</sup> However, there were other specific factors that more directly influenced one of the indicators analyzed: the case of the total cost (per user and per prescription), which could be affected by policies of rationalization of medication (generic prescribing, standardized protocols)<sup>30 31</sup> and changes in drug pricing (review of medication prices by the government), among others.

### Study limitation

This is an exploratory, longitudinal study and may have an inherent bias common to this type of study. Furthermore, the period covered is short to establish causal relationships between e-prescribing and variations in drug use indicators. However, it gives hints of some trends that are essential to conduct future impact assessment studies and it could also provide evidence on this topic. This study was carried out in 6 BHAs because at the time of study they were those BHAs with the greatest implementation grade.

### CONCLUSIONS

This study suggests that After the implementation of electronic prescribing (May 2009) in polymedicated users, the number of prescriptions per user, and the total cost per user and the total cost per prescription decreased. This study provides a very valuable approach for future impact assessment.

The electronic prescribing system allows the closest follow-up of drug use indicators in each stage (i.e number of prescriptions issued vs. dispensed), so health professionals can control risk patients in terms of rational drug use, improving quality of services and health promotion.

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~~Results indicate that there was an increase in the number of users, prescriptions and total cost; although graphically it was observed that the increase was independent from the implementation of electronic prescribing. It was suggested that the increase was probably due to the deterioration of the health of polymedicated users studied and duplication in the dispensation (due to coexistence of paper and electronic prescriptions in the same user).~~

~~Given the complexity and dynamism of the implementation of electronic prescription, there are several factors of variability, inherent or not to the deployment of the project, which can also influence the parameters related to pharmaceutical services (territory, time factor, providers, type of users, pricing policies and treatment protocols, among others). It is still too early to attribute all observed changes to electronic prescription because its integration into all elements of the health system was not fully completed at the time of study. However, the study provides a very valuable approach for future impact assessment.~~

**Contributors** IL-D collected the data, conducted the analysis and wrote the first draft of the manuscript. PM advised on design the study, data analysis and helped revise the draft of the manuscript. PL-C helped in conduct of study and data analysis. CFL helped data analysis and helped revise the draft of the manuscript. JLS contributed expertise in interpretation and analysis and helped revise the draft manuscript. AG-P contributed to design the study and expertise in interpretation and analysis. ELM contributed to the study design, contributed expertise in interpretation and analysis, and assisted in revising the draft manuscript. All authors reviewed and agreed on the submitted version of the manuscript.

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## REFERENCES

1. Government of Catalonia, Health Department. The electronic prescription (Rec@t). <http://www20.gencat.cat> (accessed 10 Jun 2014).
- ~~2. De La Puente ML, Fusté J. Health Map: a dynamic vision of health service planning in Catalonia, Spain. *Med Clin (Barc)* 2008; 131(Suppl 4):3-8.~~
2. Gilabert-Perramon A, López-Calahorra P, Escoda-Geli N, *et al.* Electronic prescription in Catalonia, Spain (Rec@t): a health tool. *Med Clin (Barc)* 2010;134(Suppl 1):49-55.
3. Decree 159/2007, of 24 July, which regulates electronic prescription and telematic processing of pharmaceutical services in charge of Catalan Health Service. DOGC num. 4934, of 26-07-2007, pp. 25.620-2. <http://www.gencat.cat> (accessed 10 Jun 2014)
4. Ammenwerth E, Schnell-Inderst P, Machan C, *et al.* The effect of electronic prescribing on medication errors and adverse drug events: a systematic review. *J Am Med Inform Assoc* 2008;15:585-600.
5. Van Doormaal JE, Van den Bemt P, Zaal RJ, *et al.* The influence that electronic prescribing has on medication errors and preventable adverse drug events: an interrupted time-series study. *J Am Med Inform Assoc* 2009;16:816-25.
6. Weingart SN, Massagli M, Cyrulik A, *et al.* Assessing the value of electronic prescribing in ambulatory care: A focus group study. *Int J Med Inform* 2009;78:571-8.
7. Lapane KL, Dubé C, Schneider KL, *et al.* Patient perceptions regarding electronic prescriptions: is the geriatric patient ready? *J Am Geriatr Soc* 2007; 55:1254-9.
8. Porteous T, Bond C, Robertson R, *et al.* Electronic transfer of prescription-related information: comparing views of patients, general practitioners, and pharmacists. *Br J Gen Pract* 2003;53:204-9.
9. Ministry of Health, Social Services and Equality. Project: Electronic prescription in the NHS (June 2014). <http://www.msssi.gob.es> (accessed 10 Jun 2014).
10. European Commission, information society and media. Case studies. <http://www.ehr-impact.eu> (accessed 10 Jun 2014).
11. Government of Balearic Islands. Electronic prescription in Balearic Islands (Jan 2010). <http://www.recetaelectronicabaleares.es> (accessed 10 Jun 2014).

12. Cannaby S, Westcott D, Pedersen CD, *et al.* The cost benefit of electronic patient referrals in Denmark: summary report. *Stud Health Technol Inform* 2004;100:238-45.

13. National Prescribing Centre, NHS. Saving time, helping patients: A good practice guide to quality repeat prescribing (Jan 2004). <http://www.npci.org.uk> (accessed 10 Jun 2014).

14. European Patients Smart Open Services. Welcome to epSOS-a European eHealth Project. <http://www.epsos.eu> (accessed 10 Jun 2014).

15. Mäkinen M, Forsström J, Aärimaa M, *et al.* A European survey on the possibilities and obstacles of electronic prescriptions in cross-border healthcare. *Telemed J E Health* 2006;12:484-9.

16. De La Puente ML, Fusté J. Health Map: a dynamic vision of health service planning in Catalonia, Spain. *Med Clin (Barc)* 2008; 131(Suppl 4):3-8.

17. Official statistics website of Catalonia (Idescat). Statistical yearbook of Catalonia. <http://www.idescat.cat> (accessed 10 Jun 2014).

18. Lizano-Díez I, Modamio P, López-Calahorra P, *et al.* Profile, cost and pattern of prescriptions for polymedicated patients in Catalonia, Spain. *BMJ Open* 2013;3:e003963.

~~18. Official statistics website of Catalonia (Idescat). Statistical yearbook of Catalonia. <http://www.idescat.cat> (accessed 10 Jun 2014).~~

19. Lizano I, Carbonell P, López P, *et al.* Impact of electronic prescription on users and the health system in Catalonia. *Gac Sanit* 2010; 24(Espec Congr 1):29.

20. World Health Organisation (WHO). Preventing chronic diseases, a vital investment. Department of Chronic Diseases and Health Promotion. Geneva, 2005. [http://www.who.int/chp/chronic\\_disease\\_report/en/](http://www.who.int/chp/chronic_disease_report/en/) (accessed 10 Jun 2014).

21. Hillestad R, Bigelow J, Bower A, *et al.* Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. *Health Aff (Millwood)* 2005;24:1103-17.

22. Suárez-Varela J, Beltrán C, Molina T, *et al.* Computer-aided prescribing: from utopia to reality. *Aten Primaria* 2005;35:451-9.

23. Mateu J, Boronat MA, Zaforteza M, *et al.* Electronic prescription: impact on pharmaceutical expenditure. *Gac Sanit* 2011;25(Espec Congr 1):7.

24. Calzón S, Mercader JJ, Montero JC, *et al.* Introduction of the electronic prescription in a primary care district: impact on pharmaceutical expenditure and the factors determining its use. *Aten Primaria* 2013;45:133-9.
25. Catalán-Arlandis, JL. The computerised prescription in Primary Care and its impact on drug spending using time series analysis. *Rev Calid Asist* 2011;26:18-27.
26. Farmaindustria. The pharmaceutical market in Spain. April 2009; Bulletin 48. <http://www.farmaindustria.es> (accessed 10 Jun 2014).
27. McMullin ST, Lonergan TP, Ryneerson CS. Twelve-month drug cost savings related to use of an electronic prescribing system with integrated decision support in primary care. *J Manag Care Pharm* 2005;11:322-32.
28. Acezat Oliva J. Impact of the use of ICT on pharmacy costs. The incorporation of the electronic prescription. *Aten Primaria* 2013;45:139-40.
29. Amirfar S, Anane S, Buck M, *et al.* Study of electronic prescribing rates and barriers identified among providers using electronic health records in New York City. *Inform Prim Care* 2011;19:91-7.
30. Crosson JC, Isaacson N, Lancaster D, *et al.* Variation in electronic prescribing implementation among twelve ambulatory practices. *J Gen Intern Med* 2008;23:364-71.
31. Fischer MA, Vogeli C, Stedman M, *et al.* Effect of electronic prescribing with formulary decision support on medication use and cost. *Arch Intern Med* 2008;168:2433-9.



Table 1 Detail on the number of total users, prescriptions and percentages in the 6 BHAs of study during the period May-December 2009.

BHAs of prescription	Total users	Total prescriptions	Average number of prescriptions per user	% Electronic prescriptions*	Users with electronic prescriptions†	% Users with electronic prescriptions‡	% Users with > 50% of electronic prescriptions‡	% Users > 90% of electronic prescriptions‡
BHA 1	107,306	438,228	4.08	42,03%	35,000	32.62%	28.55%	21.03%
BHA 2	55,776	293,860	5.27	37,69%	20,593	36.92%	32.75%	24.74%
BHA 3	72,484	329,073	4.54	33,81%	24,100	33.25%	29.55%	23.41%
BHA 4	43,731	191,705	4.38	32,96%	14,346	32.81%	28.32%	21.97%
BHA 5	72,585	351,972	4.85	29,57%	23,274	32.06%	28.18%	22.10%
BHA 6	53,511	264,308	4.94	25,06%	13,142	24.56%	21.08%	15.14%
Total	405,393	1,869,146	4.61	34.20%	130,455	32.20%	28.20%	21.50%

\* % Electronic prescriptions = (Total electronic prescriptions/Total prescriptions)\*100 = % Cumulative implementation grade (>25%)

† Users with electronic prescriptions: Users with, at least, one electronic prescription

‡ % Users with electronic prescriptions = (Users with electronic prescriptions/Total users)\*100

Results were calculated from global cumulative data in each BHA



Table 2 Detail on the number of polymedicated users, prescriptions and related drug use indicators percentages in the 6 BHAs during the post-implementation period May 2009-April 2010.

BHAs of prescription	Polymedicated users	Electronic prescriptions	Total prescriptions	% Electronic prescriptions*	Average number of prescriptions per polymedicated user	Average cost per polymedicated user	Average cost per prescription
BHA 1	241	11,708	18,243	64.18%	30.71 ± 3.01	€ 404.02 ± 48.25	€ 13.28 ± 1.89
BHA 2	112	7,497	12,149	61.71%	31.44 ± 1.97	€ 455.69 ± 48.80	€ 14.52 ± 1.53
BHA 3	297	6,099	11,976	50.93%	29.65 ± 2.82	€ 467.32 ± 70.36	€ 15.73 ± 1.38
BHA 4	275	1,995	4,026	49.55%	30.57 ± 3.83	€ 500.14 ± 88.99	€ 16.41 ± 2.34
BHA 5	284	3,796	10,133	37.46%	30.70 ± 1.56	€ 503.95 ± 70.23	€ 16.41 ± 2.02
BHA 6	366	1,322	5,554	23.80%	32 ± 3.36	€ 450.74 ± 50.30	€ 14.10 ± 0.79
<b>Total</b>	<b>1,575</b>	<b>32,417</b>	<b>62,081</b>	<b>52.22%</b>	<b>30.73 ± 1.96</b>	<b>€ 454.03 ± 35.22</b>	<b>€ 14.79 ± 0.98</b>

\* % Electronic prescriptions = (Total electronic prescriptions/Total prescriptions)\*100

Averages of monthly global data in the 6 BHAs were calculated for prescriptions/user, cost/user and cost/prescription

All data included made reference to the whole prospective follow-up period (average data resulting from 12 months, post-implementation period)

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**FIGURES**

Figure 1 Evolution of number of prescriptions per polymedicated user in the 6 BHAs of study

Figure 2 Evolution of total cost per polymedicated user in the 6 BHAs of study

Figure 3 Evolution of total cost per prescription in polymedicated users in the 6 BHAs of study

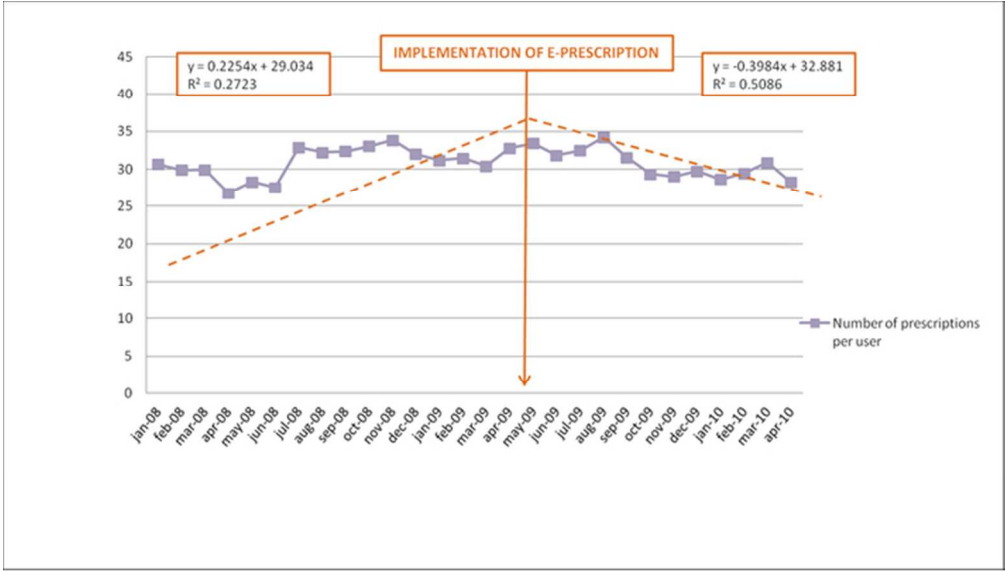
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## Online Supplementary appendices

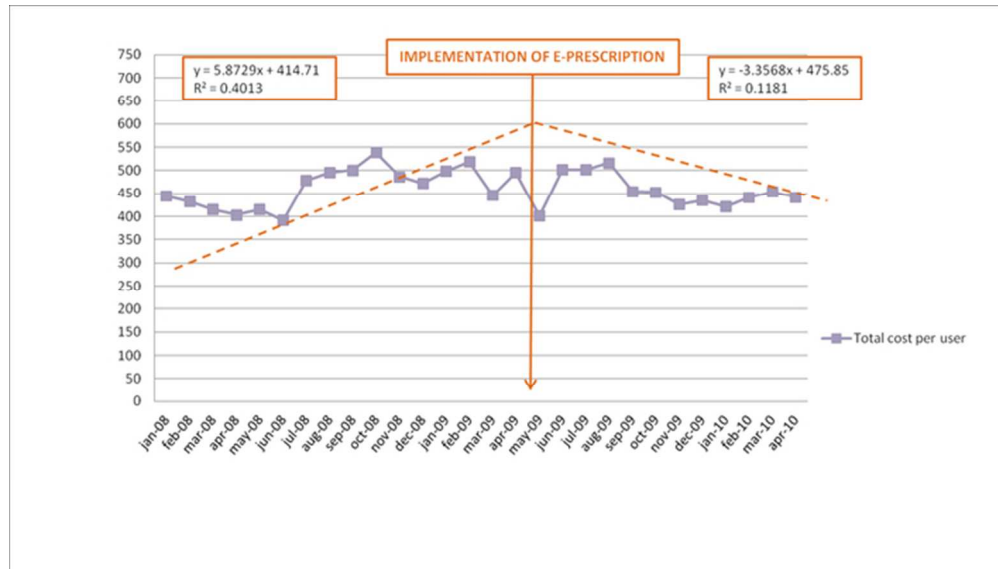
Appendix 1 Evolution of growth in number of polymedicated users in the 6 BHAs of study

Appendix 2 Evolution of number of prescriptions in polymedicated users in the 6 BHAs of study

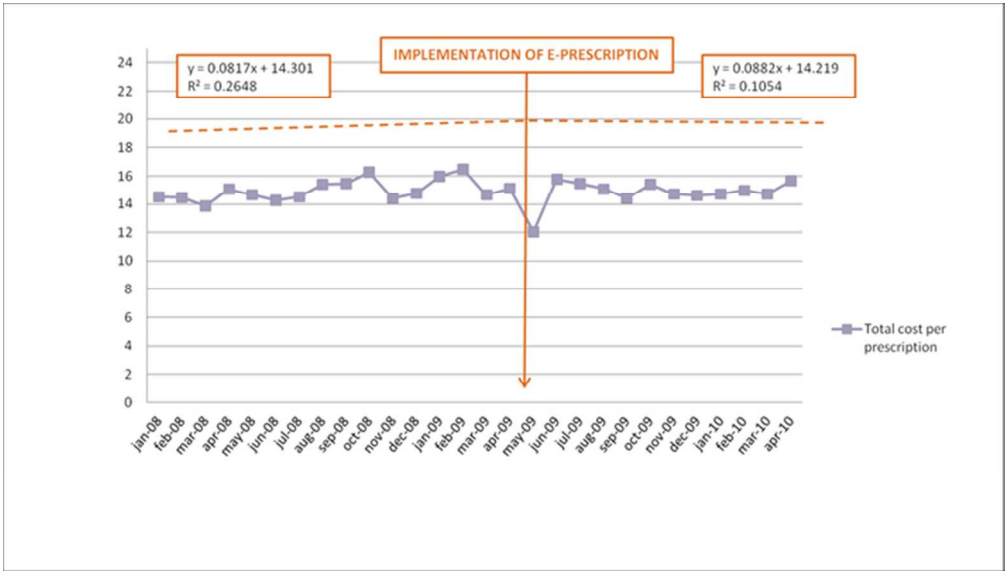
Appendix 3 Evolution of growth in total cost in polymedicated users in the 6 BHAs of study



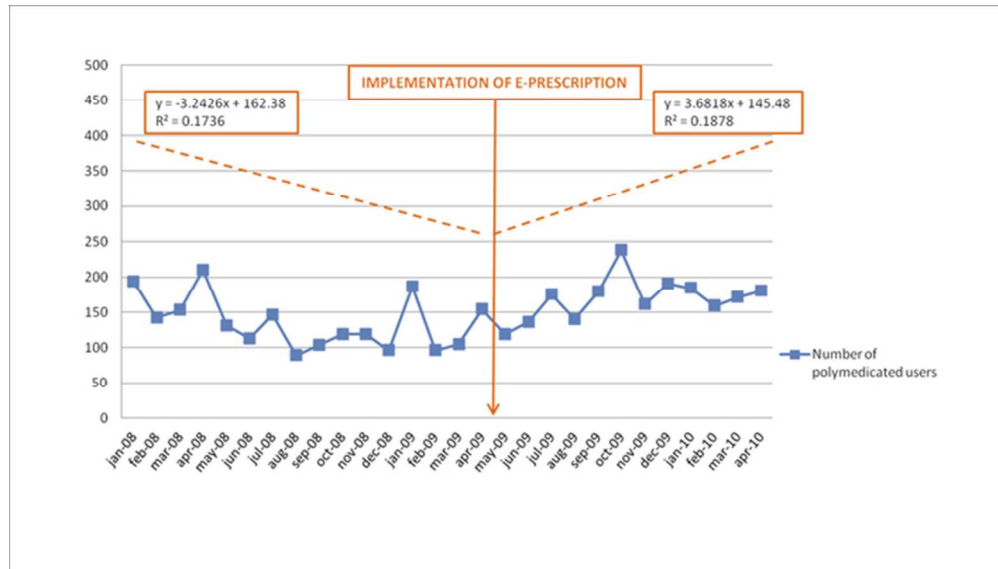
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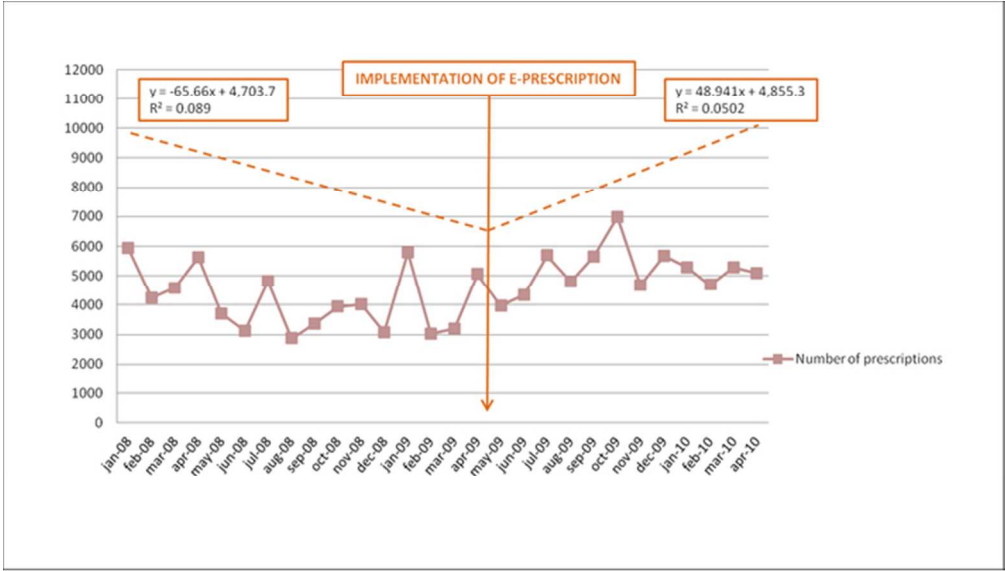
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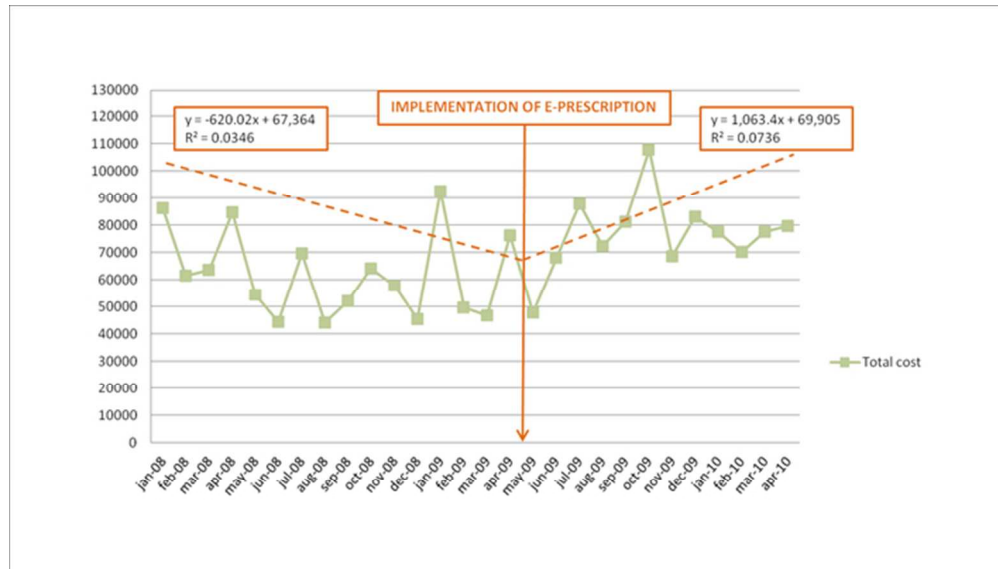


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# BMJ Open

## Evaluation of electronic prescription implementation in polymedicated users of Catalonia, Spain: a population-based longitudinal study

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**Evaluation of electronic prescription implementation in polymedicated users of Catalonia, Spain: a population-based longitudinal study**

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**Keywords:** electronic prescribing, polymedication, primary health care, drug use indicators

**Word count:** 3,243

## ABSTRACT

**Objectives:** To assess whether electronic prescribing is a comprehensive health management tool that may contribute to rational drug use, particularly in polymedicated patients receiving sixteen or more medications in the public healthcare system in the Barcelona Health Region (BHR).

**Design:** 16 months of retrospective study followed by 12 months of prospective monitoring.

**Setting:** Primary healthcare in BHR, Catalonia, Spain.

**Participants:** All insured patients, especially those who are polymedicated in 6 Basic Health Areas (BHA). Polymedicated patients were those with a consumption of  $\geq 16$  drugs/month.

**Interventions:** Monitoring demographic and consumption variables obtained from the records of prescriptions dispensed in pharmacies and charged to the public health system, as well as the resulting drug use indicators. Territorial variables related to implementation of electronic prescribing were also described and were obtained from the institutional data related to the deployment of the project.

**Main outcome measures:** Trend in drug use indicators (number of prescriptions per polymedicated user, total cost per polymedicated user and total cost per prescription) according to e-prescription implementation.

**Results:** There was a significant upward trend in the number of polymedicated users, number of prescriptions and total cost ( $p < 0.05$ ), which seemed independent from the implementation of electronic prescribing when comparing the pre and post implementation period. Prescriptions per user and cost per user showed a decrease between the pre and post implementation period, being significant in 2 BHAs ( $p < 0.05$ ).

**Conclusions:** Results suggest that after the implementation of electronic prescribing, the rationality of prescribing in polymedicated patients improved. In addition, this study provides a very valuable approach for future impact assessment.

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**Strengths and limitations of this study**

- This is a novel study that describes the implementation of an e-prescribing system in polymedicated users. It establishes many drug use indicators (demographic and consumption variables) and represents a very important step towards an integral and integrated pharmaceutical management in health services.
- An economic impact study could not be carried out because it was still too early to attribute all observed changes to electronic prescriptions because its integration into all elements of the health system was not fully completed at the time of study.
- This is the first report showing results of drug use indicators in polymedicated patients with e-prescriptions. It provides a very valuable approach for future impact assessment.

## INTRODUCTION

Rec@t is the electronic prescription system in the autonomous region of Catalonia (north-eastern Spain).<sup>1</sup> The Catalan Health Service has played an active part leading the development of the project, as guarantor of public health services that purchases and evaluates healthcare depending on the needs of the population.

Rec@t is a strategic healthcare project that aims to provide advantages concerning quality, accessibility, safety, efficiency, continuity of care, and rational drug use.<sup>2</sup> The implementation of this system is a comprehensive health management tool that addresses the entire process involved in pharmaceutical services. This includes everything, from prescribing and dispensing in community pharmacies to the assessment and payment of the benefit.<sup>3</sup>

It entails a different healthcare model than it had thus far, highlighting in particular the elimination of paper-based prescribing. The key element that helps serve this task is the medication plan,<sup>1</sup> which is the printed sheet that is given to patients and contains all the information necessary to be able to follow the treatment correctly (i.e. dose and frequency of administration). It facilitates the feedback between prescribers and dispensers, forming a new communication channel between them and helping to prevent medication errors and duplicities of treatment.<sup>2-6</sup> Therefore, electronic prescribing is an important tool to control chronic patients, the elderly and polymedicated users, who generate the greatest interest because of their therapeutic complexity, high drug consumption and total cost for the healthcare system.<sup>7-8</sup>

Rec@t implementation began in 2007 after an initial pilot experience in 2006 that proved the feasibility of the designed system. The progressive extension of electronic prescriptions started, reaching 100% of the equipment in late 2010.<sup>2</sup> Currently, it is considered fully complete in primary care, and in specialty care it has reached significant levels on the extent and volume of prescriptions issued and dispensed (98.33% of prescriptions were electronic in May 2014), so it is expected to be completed this year.<sup>9</sup> Community pharmacies completely work with electronic prescribing, given that more than 90% of prescriptions dispensed are already in electronic format. More than 12,500 physicians who have joined the system so far have made prescriptions to more than 5 million patients, reaching more than 275 million medications dispensed.<sup>10</sup>

Regarding other Spanish autonomous regions, similar projects in electronic prescribing were already underway in primary care at the same time as Catalonia. The most advanced of which were in Andalusia (southern Spain),<sup>10</sup> and in Balearic Islands (eastern Spain).<sup>11</sup> At an international level, it is noteworthy to mention experiences in Denmark,<sup>12</sup> Sweden,<sup>10</sup> and England,<sup>10 13</sup> where healthcare organizations are involved in improving quality of prescriptions through e-prescribing systems along with Spain.<sup>9</sup> The ultimate goal of these experiences is to be brought into a single overall system allowing interoperability in the near future, both nationally and throughout Europe.<sup>9 14 15</sup>

From an international point of view, even though the electronic prescribing system involves a change of paradigm that will enable a better assessment of drug use, there is a lack of evidence reported in the literature in terms of health outcomes evaluation.

The aim of our study was to assess whether electronic prescribing may contribute to rational drug use, particularly in polymedicated patients receiving sixteen or more medications in the public healthcare system in the Barcelona Health Region (BHR). These results will be useful to get prior information for future impact assessment of this technology on risk population.

**METHOD**

**Design and setting of the study**

Longitudinal study in a primary care setting, conducted on the general population and polymedicated patients in those Basic Health Areas (BHAs) in BHR with the greatest cumulative grade of implementation in e-prescription between May and December of 2009. Monitoring included 16 months of retrospective study (January 2008-April 2009) and 12 months of prospective follow-up from the beginning of the implementation of Rec@t in BHR (May 2009) to April 2010. This was considered a sufficiently large analysis for the objectives to be achieved (28 months).

The Catalan healthcare model is decentralised, to better know the health needs of the population and develop a better relationship with providers in each health region and their respective BHAs. BHAs are the basic territorial units around which primary healthcare services are organised (areas or municipalities), according to the population's access to the services and the efficiency in organising health resources.<sup>1,16</sup> In terms of prescriptions billing, during the period 2008-2010, the average of total prescriptions per year in Catalonia was 143,753,915 ± 4,500,218 (99,786,576 ± 1,251,654 in BHR). According to the average yearly number of prescriptions per capita and cost per

prescription, both indicators were similar in Catalonia and BHR:  $18.98 \pm 0.50$  vs.  $18.94 \pm 0.78$  and  $13.24 \pm 0.18$  vs.  $13.25 \pm 0.19$  respectively.<sup>17</sup>

A polymedicated user in the present study was defined as someone receiving 16 or more active principles in a month, according to the Efficiency Indicators in Primary Care that are periodically evaluated by an internal Management Committee in the Catalan Health Service (macromanagement level).<sup>18</sup>

### Data source

The study used population data from 2008, 2009 and 2010 Catalonia censuses.<sup>17</sup> Records of billed prescriptions were also utilized, based on both paper and electronic prescriptions that were dispensed in community pharmacies and charged to the Catalan Health Service. This information was obtained by means of the personal healthcare card, the document that provides citizens with access to the centres, services and benefits of the public health system (these services include drugs subsidised by the Catalan Health Service).<sup>1</sup> This information is stored monthly in a computer system, which allows the design and gathering of information required for the management and monitoring of pharmaceutical services.

Prescriptions in paper format are usually issued for 3 months ("chronic patients program" in primary care setting) and electronic prescriptions are usually issued for 12 months (maximum); at least once a year patients visit the doctor to renew them.

Polymedicated users were selected monthly, so polymedicated population varied throughout the whole study (28 months, which involved 28 data analysis). Due to the fact that each user had its own identification code, given by the personal healthcare card, subsequent analyses could be carried out so as to determine monthly duplicities of users.

### Ethical statement

Ethics approval was not required since it was a secondary analysis of suitably anonymised datasets. It was not an experimental treatment, patients were not recruited. The study was unfunded.

### Variables of the study

The variables used to analyze the implementation of e-prescription were as follows.



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Territorial: number and % of BHAs implemented, % of primary care centres implemented, grade of implementation, number of general practitioners (e-prescription prescribers), % of general practitioners implemented, number of community pharmacies which dispensed electronic prescriptions and % of community pharmacies implemented. Grade of implementation is the percentage of electronic prescribing on the total number of prescriptions billed (sum of prescriptions on paper and electronic format) for a given month or a specific time period (cumulative implementation grade). Depending on the variable described, the grade of implementation is indicative of the deployment of electronic prescription in the territory (i.e. in a given BHA) or the percentage of electronic prescriptions prescribed to an individual in a given period. Demographic: number and % of users implemented, % of users with more than 50% of electronic prescriptions and % of users with more than 90% of electronic prescriptions, number of polymedicated users implemented. By definition it is assumed that total percentage of users with electronic prescription includes those users with more than 50% and 90% implementation of electronic records, and that those users with more than 90% implementation rates are consequently also included in the user group with implementation greater than 50%.

Consumption: number of total prescriptions (sum of prescriptions on paper and electronic format), number and % of electronic prescriptions, and total cost of medications dispensed. Total cost refers to the total cost of medications dispensed (the amount of reimbursement by the Catalan Health Service plus the out-of-pocket amount paid by patients). Drug use indicators were calculated from the following variables: number of prescriptions per polymedicated user (total and electronic format), total cost per polymedicated user and total cost per prescription.

**Literature review**

A systematic search was conducted (April 2014) through the PubMed database to identify the available evidence on electronic prescribing related to polypharmacy and health expenditure or cost analysis. The terms to run the search were located by the vocabulary Medical Subject Headings, with which the articles are indexed in the MEDLINE database. In order to complete this search and extend the results, additional searches combining free terms were also conducted. All search strategies (12) resulted in only 78 references. The studies identified through this search were evaluated by two independent reviewers to assess their inclusion in this document.

## Data processing and statistical analysis

A database was designed. ANOVA and Student's t-tests were used to determine the statistical significance ( $p < 0.05$ ) of the differences using the SPSS version 20.0 statistics program. Regression testing was also performed in order to describe the tendency of the indicators relating to pharmaceutical services.

## RESULTS

### General population

According to internal data in the Catalan Health Service and coinciding with published information,<sup>19</sup> the project achieved the implementation in 273 BHAs, representing 75% of the total territory in 2009. In December 2009, a cumulative total of 16 million electronic prescriptions dispensed were reached, adding more than 800,000 of the insured population and more than 5,000 health professionals (3,289 general practitioners and 2,497 pharmacists). Taking into account the progressive inclusion of primary care teams of BHR in the project during December 2009, the deployment of e-prescribing in primary care settings was considered complete (13% of patients who needed a prescription received an electronic one, 67.4% of which had more than 90% of their dispensed medications through e-prescribing). Therefore, electronic prescriptions could be dispensed throughout Catalonia.

In late 2009, 91% of primary care centers were prescribing electronically and the remaining 9% were under implementation of the tasks prior to incorporation, i.e adaptation of computer applications or training professionals.

During 2009, electronic prescription systems were implemented in 174 BHAs of BHR (82.1% of total BHAs in BHR). In total, 2,255,724 electronic prescriptions were billed, which accounted for 3% of total prescriptions billed. 494,628 users were included (3% of total users with prescriptions in BHR). In the included BHAs, 1,810 general practitioners (47% of total in BHR) prescribed in electronic format, and 95.5% of community pharmacies in the territory dispensed prescriptions of this type.

Out of the 28 BHAs in BHR that implemented electronic prescribing in May 2009, only 6 reached the highest cumulative implementation grade ( $> 25\%$ ) during the period May-December 2009.

General details about the number of total insured users assigned to each of the 6 BHAs and the percentage of total electronic prescriptions during the period May-December 2009 are shown in Table 1.

**Polymedicated users**

Data concerning e-prescription in polymedicated users in these BHAs are disclosed in Table 2. In the 28 months study period, the 6 BHAs met a monthly average of  $169 \pm 31$  (min 89; max 238) polymedicated users. 1,575 polymedicated users were analyzed; 54.4% of them were only polymedicated in 1 month of the study and 4% of them had that condition in  $\geq 10$  months; there were no users being polymedicated during  $> 20$  months.

There was a significant upward trend in the number of polymedicated users, number of prescriptions and total cost ( $p<0.05$ ), comparing the period January 2008-April 2009 with May 2009-April 2010. As depicted in online supplementary appendixes 1-3, the increase in those indicators seem independent from the implementation of electronic prescribing. Individually, 5 of the 6 BHAs showed this increase in those indicators, with the increase being significant in 4 of them ( $p<0.05$ ). On the other hand, prescriptions per user and cost per user showed a decrease between the pre and post implementation period, whereas cost per prescription showed no variation. The decrease in prescription per user and cost per user was evident for both overall and 3 of the 6 BHAs individually, with results being significant in 2 of them ( $p<0.05$ ). A slight upward trend is observed graphically in those 2 indicators prior to the implementation of electronic prescription; after this point the overall trend was decreasing (Figures 1-3).

**DISCUSSION**

In order to explain the results from the study conducted, it should be noted that this is an exploratory and longitudinal study about the implementation and deployment of electronic prescription in polymedicated users belonging to particular BHAs. The fact of studying pharmaceutical services in polymedicated users using new technologies as e-prescription may be important for health authorities because it could allow a step forward in the monitoring of the high costs that they entail and therefore manage chronic care patients more properly.<sup>18 20</sup> Hence this study was designed to describe the tendency of some drug use indicators in the studied population.

It was still early to conduct a proper impact analysis of electronic prescription on all implemented users and population subgroups (by age, gender, pathology, polymedicated users), because it would be essential that total deployment of electronic

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3 prescription and subsequent penetration into the population were fulfilled.<sup>10 21</sup> The  
4 Catalan Health Service considered that the deployment of electronic prescription in the  
5 territory had finished in primary care setting at the time of study, but the truth is that all  
6 BHAs in Catalonia were not implemented. Impact studies could not be carried out until  
7 all BHAs were at least 80% implemented and had between six months and one year of  
8 experience with electronic prescription. In case of insured users, the implementation  
9 criterion could be considered as more than 90% of electronic prescriptions prescribed.  
10 In this sense, results derived from the measurement of indicators suggest previous  
11 approaches in our setting, and are essential to strengthen and guide any future  
12 evaluation of impact in primary care and in those areas where implementation is  
13 developing (specialty care, emergency departments, mental health centers and nursing  
14 homes).

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23 There are currently no national published studies showing results in polymedicated  
24 populations as presented here. In the general population, some autonomous  
25 communities in Spain which have been operating with e-prescription (i.e. Andalusia,  
26 Balearic Islands, Community of Valencia, Galicia) have found that visits to  
27 professionals have been reduced by between 15% and 60% depending on the profile of  
28 the population being observed.<sup>10 22</sup> However, it is difficult to measure in economic  
29 terms the savings to the health system generated by a reduction in the number of visits  
30 as this cannot yet be quantified precisely. What has been determined, although there is  
31 controversy in the published results, is that in many of these communities the switch to  
32 electronic prescriptions coincided with an increase in health spending, as well as in  
33 number of prescriptions issued and total cost per user,<sup>23-25</sup> the latter differing from the  
34 results presented here (a decrease in cost per user between the pre and post  
35 implementation period was observed). The increase in drug expenditure may not always  
36 be significantly related to implementation of e-prescription, and could even be  
37 associated with the personal profile of users included in the e-prescription system and  
38 their health condition<sup>23</sup> (i.e. polymedicated users). Furthermore, specialized reports on  
39 public pharmaceutical expenditure issues show that the fluctuation in the number of  
40 prescriptions always follows a seasonal pattern in Spain.<sup>26</sup> Throughout the year the  
41 number of prescriptions increases in January, June and October, mainly due to visits to  
42 physicians before (June) and after (January and October) the holiday period; this peak  
43 can also be observed for Easter holiday season (i.e. March 2008 and 2010; April 2009).  
44 In addition, during the study period, the increase in prescriptions every April was due to  
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the annual review of the reference pricing system by the government, which reduces the price of drugs from year to year. The new prices came into effect in May and therefore the market share of these products and the turnover rate in pharmacies increased (and consequently the number of patients and billed prescriptions) in the previous month. In either case, it is important to highlight that all these monthly increases are merely transitory and they are irrelevant in the medium-long term evolution of time series, so they do not set a trend only by themselves.

Internationally, there are studies that describe quantitatively the influence of e-prescribing on implementation of pharmaceutical services and other elements of the health system. These results are mainly related to potential savings of e-prescribing (total cost of time taken by the practitioners, medical attendance, less equipment and operational costs).<sup>10-13 27</sup> However, there are none that assess drug use indicators in polymedicated users and therefore comparable to the results obtained in the present study.

Qualitative results were mostly observed in the 6 BHAs selected. Those results were inherent to the development of electronic prescription over the territories (i.e. increase in electronic prescribing and a decrease of the proportion of paper prescriptions). However, it is important to highlight some quantitatively different aspects have been significant since the introduction of electronic prescribing in the territory in May 2009. This includes the decrease in the number of prescriptions per user, and total cost per user. In contrast, there was an increase in the number of prescriptions and the total cost, which could be attributed to the progressive deterioration of polymedicated users' health and the consequent need for more complex treatments such as the prescribing of therapeutic innovations, which are more expensive. In addition, duplication in the dispensation (due to coexistence of paper and electronic prescriptions in the same user) was also suggested as cause of that increase.<sup>28</sup> It is noteworthy that the results of any health intervention begin to appear at least one year after its start, and in this regard it would be necessary to assess the evolution over the years 2010 and 2011 to see whether there are more significant changes on any of the measured indicators. The implementation of electronic prescribing was a dynamic process that followed different patterns depending on the time (different degree of implementation throughout the development, period of adaptation to the new tool), territory, providers (often there was variability between providers and even within the same provider), type of users (polymedicated/non polymedicated, by age group, etc), and healthcare professionals,

among others, which will hinder future development of common profiles and design a model of this implementation globally.<sup>28 29</sup> However, there were other specific factors that more directly influenced one of the indicators analyzed: the case of the total cost (per user and per prescription), which could be affected by policies of rationalization of medication (generic prescribing, standardized protocols)<sup>30 31</sup> and changes in drug pricing (review of medication prices by the government), among others.

### Study limitation

This is an exploratory, longitudinal study and may have an inherent bias common to this type of study. Furthermore, the period covered is short to establish causal relationships between e-prescribing and variations in drug use indicators. However, it gives hints of some trends that are essential to conduct future impact assessment studies and it could also provide evidence on this topic. This study was carried out in 6 BHAs because at the time of study they were those BHAs with the greatest implementation grade.

### CONCLUSIONS

Results suggest that after the implementation of electronic prescribing (May 2009), the rationality of prescribing in polymedicated patients improved. This study provides a very valuable approach for future impact assessment.

The electronic prescribing system allows the closest follow-up of drug use indicators in each stage (i.e. number of prescriptions issued vs. dispensed), so health professionals can control risk patients in terms of rational drug use, improving quality of services and health promotion.

**Contributors** IL-D collected the data, conducted the analysis and wrote the first draft of the manuscript. PM advised on design the study, data analysis and helped revise the draft of the manuscript. PL-C helped in conduct of study and data analysis. CFL helped data analysis and helped revise the draft of the manuscript. JLS contributed expertise in interpretation and analysis and helped revise the draft manuscript. AG-P contributed to design the study and expertise in interpretation and analysis. ELM contributed to the study design, contributed expertise in interpretation and analysis, and assisted in revising the draft manuscript. All authors reviewed and agreed on the submitted version of the manuscript.

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**Competing interests** None

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For peer review only



## REFERENCES

1. Government of Catalonia, Health Department. The electronic prescription (Rec@t). <http://www20.gencat.cat> (accessed 10 Jun 2014).
2. Gilabert-Perramon A, López-Calahorra P, Escoda-Geli N, *et al.* Electronic prescription in Catalonia, Spain (Rec@t): a health tool. *Med Clin (Barc)* 2010;134(Suppl 1):49-55.
3. Decree 159/2007, of 24 July, which regulates electronic prescription and telematic processing of pharmaceutical services in charge of Catalan Health Service. DOGC num. 4934, of 26-07-2007, pp. 25.620-2. <http://www.gencat.cat> (accessed 10 Jun 2014)
4. Ammenwerth E, Schnell-Inderst P, Machan C, *et al.* The effect of electronic prescribing on medication errors and adverse drug events: a systematic review. *J Am Med Inform Assoc* 2008;15:585-600.
5. Van Doormaal JE, Van den Bemt P, Zaal RJ, *et al.* The influence that electronic prescribing has on medication errors and preventable adverse drug events: an interrupted time-series study. *J Am Med Inform Assoc* 2009;16:816-25.
6. Weingart SN, Massagli M, Cyrulik A, *et al.* Assessing the value of electronic prescribing in ambulatory care: A focus group study. *Int J Med Inform* 2009;78:571-8.
7. Lapane KL, Dubé C, Schneider KL, *et al.* Patient perceptions regarding electronic prescriptions: is the geriatric patient ready? *J Am Geriatr Soc* 2007; 55:1254-9.
8. Porteous T, Bond C, Robertson R, *et al.* Electronic transfer of prescription-related information: comparing views of patients, general practitioners, and pharmacists. *Br J Gen Pract* 2003;53:204-9.
9. Ministry of Health, Social Services and Equality. Project: Electronic prescription in the NHS (June 2014). <http://www.msssi.gob.es> (accessed 10 Jun 2014).
10. European Commission, information society and media. Case studies. <http://www.ehr-impact.eu> (accessed 10 Jun 2014).
11. Government of Balearic Islands. Electronic prescription in Balearic Islands (Jan 2010). <http://www.recetaelectronicabaleares.es> (accessed 10 Jun 2014).
12. Cannaby S, Westcott D, Pedersen CD, *et al.* The cost benefit of electronic patient referrals in Denmark: summary report. *Stud Health Technol Inform* 2004;100:238-45.



13. National Prescribing Centre, NHS. Saving time, helping patients: A good practice guide to quality repeat prescribing (Jan 2004). <http://www.npci.org.uk> (accessed 10 Jun 2014).

14. European Patients Smart Open Services. Welcome to epSOS-a European eHealth Project. <http://www.epsos.eu> (accessed 10 Jun 2014).

15. Mäkinen M, Forsström J, Äärimaa M, *et al.* A European survey on the possibilities and obstacles of electronic prescriptions in cross-border healthcare. *Telemed J E Health* 2006;12:484-9.

16. De La Puente ML, Fusté J. Health Map: a dynamic vision of health service planning in Catalonia, Spain. *Med Clin (Barc)* 2008; 131(Suppl 4):3-8.

17. Official statistics website of Catalonia (Idescat). Statistical yearbook of Catalonia. <http://www.idescat.cat> (accessed 10 Jun 2014).

18. Lizano-Díez I, Modamio P, López-Calahorra P, *et al.* Profile, cost and pattern of prescriptions for polymedicated patients in Catalonia, Spain. *BMJ Open* 2013;3:e003963.

19. Lizano I, Carbonell P, López P, *et al.* Impact of electronic prescription on users and the health system in Catalonia. *Gac Sanit* 2010; 24(Espec Congr 1):29.

20. World Health Organisation (WHO). Preventing chronic diseases, a vital investment. Department of Chronic Diseases and Health Promotion. Geneva, 2005. [http://www.who.int/chp/chronic\\_disease\\_report/en/](http://www.who.int/chp/chronic_disease_report/en/) (accessed 10 Jun 2014).

21. Hillestad R, Bigelow J, Bower A, *et al.* Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. *Health Aff (Millwood)* 2005;24:1103-17.

22. Suárez-Varela J, Beltrán C, Molina T, *et al.* Computer-aided prescribing: from utopia to reality. *Aten Primaria* 2005;35:451-9.

23. Mateu J, Boronat MA, Zaforteza M, *et al.* Electronic prescription: impact on pharmaceutical expenditure. *Gac Sanit* 2011;25(Espec Congr 1):7.

24. Calzón S, Mercader JJ, Montero JC, *et al.* Introduction of the electronic prescription in a primary care district: impact on pharmaceutical expenditure and the factors determining its use. *Aten Primaria* 2013;45:133-9.

25. Catalán-Arlandis, JL. The computerised prescription in Primary Care and its impact on drug spending using time series analysis. *Rev Calid Asist* 2011;26:18-27.

26. Farmaindustria. The pharmaceutical market in Spain. April 2009; Bulletin 48. <http://www.farmaindustria.es> (accessed 10 Jun 2014).

- 1  
2  
3 27. McMullin ST, Lonergan TP, Ryneerson CS. Twelve-month drug cost savings  
4 related to use of an electronic prescribing system with integrated decision support  
5 in primary care. *J Manag Care Pharm* 2005;11:322-32.  
6  
7  
8 28. Acezat Oliva J. Impact of the use of ICT on pharmacy costs. The incorporation of  
9 the electronic prescription. *Aten Primaria* 2013;45:139-40.  
10  
11 29. Amirfar S, Anane S, Buck M, *et al.* Study of electronic prescribing rates and  
12 barriers identified among providers using electronic health records in New York  
13 City. *Inform Prim Care* 2011;19:91-7.  
14  
15 30. Crosson JC, Isaacson N, Lancaster D, *et al.* Variation in electronic prescribing  
16 implementation among twelve ambulatory practices. *J Gen Intern Med*  
17 2008;23:364-71.  
18  
19 31. Fischer MA, Vogeli C, Stedman M, *et al.* Effect of electronic prescribing with  
20 formulary decision support on medication use and cost. *Arch Intern Med*  
21 2008;168:2433-9.  
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Table 1 Detail on the number of total users, prescriptions and percentages in the 6 BHAs of study during the period May-December 2009.

BHAs of prescription	Total users	Total prescriptions	Average number of prescriptions per user	% Electronic prescriptions*	Users with electronic prescriptions†	% Users with electronic prescriptions‡	% Users with > 50% of electronic prescriptions‡	% Users > 90% of electronic prescriptions‡
BHA 1	107,306	438,228	4.08	42,03%	35,000	32.62%	28.55%	21.03%
BHA 2	55,776	293,860	5.27	37,69%	20,593	36.92%	32.75%	24.74%
BHA 3	72,484	329,073	4.54	33,81%	24,100	33.25%	29.55%	23.41%
BHA 4	43,731	191,705	4.38	32,96%	14,346	32.81%	28.32%	21.97%
BHA 5	72,585	351,972	4.85	29,57%	23,274	32.06%	28.18%	22.10%
BHA 6	53,511	264,308	4.94	25,06%	13,142	24.56%	21.08%	15.14%
Total	405,393	1,869,146	4.61	34.20%	130,455	32.20%	28.20%	21.50%

\* % Electronic prescriptions = (Total electronic prescriptions/Total prescriptions)\*100 = % Cumulative implementation grade (>25%)

† Users with electronic prescriptions: Users with, at least, one electronic prescription

‡ % Users with electronic prescriptions = (Users with electronic prescriptions/Total users)\*100

Results were calculated from global cumulative data in each BHA

Table 2 Detail on the number of polymedicated users, prescriptions and related drug use indicators in the 6 BHAs during the post-implementation period May 2009-April 2010.

BHAs of prescription	Polymedicated users	Electronic prescriptions	Total prescriptions	% Electronic prescriptions *	Average number of prescriptions per polymedicated user	Average cost per polymedicated user	Average cost per prescription
BHA 1	241	11,708	18,243	64.18%	30.71 ± 3.01	€ 404.02 ± 48.25	€ 13.28 ± 1.89
BHA 2	112	7,497	12,149	61.71%	31.44 ± 1.97	€ 455.69 ± 48.80	€ 14.52 ± 1.53
BHA 3	297	6,099	11,976	50.93%	29.65 ± 2.82	€ 467.32 ± 70.36	€ 15.73 ± 1.38
BHA 4	275	1,995	4,026	49.55%	30.57 ± 3.83	€ 500.14 ± 88.99	€ 16.41 ± 2.34
BHA 5	284	3,796	10,133	37.46%	30.70 ± 1.56	€ 503.95 ± 70.23	€ 16.41 ± 2.02
BHA 6	366	1,322	5,554	23.80%	32 ± 3.36	€ 450.74 ± 50.30	€ 14.10 ± 0.79
<b>Total</b>	<b>1,575</b>	<b>32,417</b>	<b>62,081</b>	<b>52.22%</b>	<b>30.73 ± 1.96</b>	<b>€ 454.03 ± 35.22</b>	<b>€ 14.79 ± 0.98</b>

\* % Electronic prescriptions = (Total electronic prescriptions/Total prescriptions)\*100

Averages of monthly global data in the 6 BHAs were calculated for prescriptions/user, cost/user and cost/prescription

All data included made reference to the whole prospective follow-up period (average data resulting from 12 months, post-implementation period)

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**FIGURES**

Figure 1 Evolution of number of prescriptions per polymedicated user in the 6 BHAs of study

Figure 2 Evolution of total cost per polymedicated user in the 6 BHAs of study

Figure 3 Evolution of total cost per prescription in polymedicated users in the 6 BHAs of study

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## Online Supplementary appendices

Appendix 1 Evolution of growth in number of polymedicated users in the 6 BHAs of study

Appendix 2 Evolution of number of prescriptions in polymedicated users in the 6 BHAs of study

Appendix 3 Evolution of growth in total cost in polymedicated users in the 6 BHAs of study

**Evaluation of electronic prescription implementation in polymedicated users of Catalonia, Spain: a population-based longitudinal study**

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**Keywords:** electronic prescribing, polymedication, primary health care, drug use indicators

**Word count:** 3,243 ~~3,232~~

## ABSTRACT

**Objectives:** To assess whether electronic prescribing is a comprehensive health management tool that may contribute to rational drug use, particularly in polymedicated patients receiving sixteen or more medications in the public healthcare system in the Barcelona Health Region (BHR).

**Design:** 16 months of retrospective study followed by 12 months of prospective monitoring.

**Setting:** Primary healthcare in BHR, Catalonia, Spain.

**Participants:** All insured patients, especially those who are polymedicated in 6 Basic Health Areas (BHA). Polymedicated patients were those with a consumption of  $\geq 16$  drugs/month.

**Interventions:** Monitoring demographic and consumption variables obtained from the records of prescriptions dispensed in pharmacies and charged to the public health system, as well as the resulting drug use indicators. Territorial variables related to implementation of electronic prescribing were also described and were obtained from the institutional data related to the deployment of the project.

**Main outcome measures:** Trend in drug use indicators (number of prescriptions per polymedicated user, total cost per polymedicated user and total cost per prescription) according to e-prescription implementation.

**Results:** There was a significant upward trend in the number of polymedicated users, number of prescriptions and total cost ( $p < 0.05$ ), which seemed independent from the implementation of electronic prescribing when comparing the pre and post implementation period. Prescriptions per user and cost per user showed a decrease between the pre and post implementation period, being significant in 2 BHAs ( $p < 0.05$ ).

**Conclusions:** Results suggest that after the implementation of electronic prescribing, the rationality of prescribing in polymedicated patients improved ~~drug use indicators decreased in polymedicated patients~~. In addition, this study provides a very valuable approach for future impact assessment.



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**Strengths and limitations of this study**

- This is a novel study that describes the implementation of an e-prescribing system in polymedicated users. It establishes many drug use indicators (demographic and consumption variables) and represents a very important step towards an integral and integrated pharmaceutical management in health services.
- An economic impact study could not be carried out because it was still too early to attribute all observed changes to electronic prescriptions because its integration into all elements of the health system was not fully completed at the time of study.
- This is the first report showing results of drug use indicators in polymedicated patients with e-prescriptions. It provides a very valuable approach for future impact assessment.

## INTRODUCTION

Rec@t is the electronic prescription system in the autonomous region of Catalonia (north-eastern Spain).<sup>1</sup> The Catalan Health Service has played an active part leading the development of the project, as guarantor of public health services that purchases and evaluates healthcare depending on the needs of the population.

Rec@t is a strategic healthcare project that aims to provide advantages concerning quality, accessibility, safety, efficiency, continuity of care, and rational drug use.<sup>2</sup> The implementation of this system is a comprehensive health management tool that addresses the entire process involved in pharmaceutical services. This includes everything, from prescribing and dispensing in community pharmacies to the assessment and payment of the benefit.<sup>3</sup>

It entails a different healthcare model than it had thus far, highlighting in particular the elimination of paper-based prescribing. The key element that helps serve this task is the medication plan,<sup>1</sup> which is the printed sheet that is given to patients and contains all the information necessary to be able to follow the treatment correctly (i.e. dose and frequency of administration). It facilitates the feedback between prescribers and dispensers, forming a new communication channel between them and helping to prevent medication errors and duplicities of treatment.<sup>2-6</sup> Therefore, electronic prescribing is an important tool to control chronic patients, the elderly and polymedicated users, who generate the greatest interest because of their therapeutic complexity, high drug consumption and total cost for the healthcare system.<sup>7-8</sup>

Rec@t implementation began in 2007 after an initial pilot experience in 2006 that proved the feasibility of the designed system. The progressive extension of electronic prescriptions started, reaching 100% of the equipment in late 2010.<sup>2</sup> Currently, it is considered fully complete in primary care, and in specialty care it has reached significant levels on the extent and volume of prescriptions issued and dispensed (98.33% of prescriptions were electronic in May 2014), so it is expected to be completed this year.<sup>9</sup> Community pharmacies completely work with electronic prescribing, given that more than 90% of prescriptions dispensed are already in electronic format. More than 12,500 physicians who have joined the system so far have made prescriptions to more than 5 million patients, reaching more than 275 million medications dispensed.<sup>10</sup>

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Regarding other Spanish autonomous regions, similar projects in electronic prescribing were already underway in primary care at the same time as Catalonia. The most advanced of which were in Andalusia (southern Spain),<sup>10</sup> and in Balearic Islands (eastern Spain).<sup>11</sup> At an international level, it is noteworthy to mention experiences in Denmark,<sup>12</sup> Sweden,<sup>10</sup> and England,<sup>10 13</sup> where healthcare organizations are involved in improving quality of prescriptions through e-prescribing systems along with Spain.<sup>9</sup> The ultimate goal of these experiences is to be brought into a single overall system allowing interoperability in the near future, both nationally and throughout Europe.<sup>9 14 15</sup>

From an international point of view, even though the electronic prescribing system involves a change of paradigm that will enable a better assessment of drug use, there is a lack of evidence reported in the literature in terms of health outcomes evaluation.

The aim of our study was to assess whether electronic prescribing may contribute to rational drug use, particularly in polymedicated patients receiving sixteen or more medications in the public healthcare system in the Barcelona Health Region (BHR). These results will be useful to get prior information for future impact assessment of this technology on risk population.

**METHOD**

**Design and setting of the study**

Longitudinal study in a primary care setting, conducted on the general population and polymedicated patients in those Basic Health Areas (BHAs) in BHR with the greatest cumulative grade of implementation in e-prescription between May and December of 2009. Monitoring included 16 months of retrospective study (January 2008-April 2009) and 12 months of prospective follow-up from the beginning of the implementation of Rec@t in BHR (May 2009) to April 2010. This was considered a sufficiently large analysis for the objectives to be achieved (28 months).

The Catalan healthcare model is decentralised, to better know the health needs of the population and develop a better relationship with providers in each health region and their respective BHAs. BHAs are the basic territorial units around which primary healthcare services are organised (areas or municipalities), according to the population's access to the services and the efficiency in organising health resources.<sup>1,16</sup> In terms of prescriptions billing, during the period 2008-2010, the average of total prescriptions per year in Catalonia was 143,753,915 ± 4,500,218 (99,786,576 ± 1,251,654 in BHR). According to the average yearly number of prescriptions per capita and cost per

prescription, both indicators were similar in Catalonia and BHR:  $18.98 \pm 0.50$  vs.  $18.94 \pm 0.78$  and  $13.24 \pm 0.18$  vs.  $13.25 \pm 0.19$  respectively.<sup>17</sup>

A polymedicated user in the present study was defined as someone receiving 16 or more active principles in a month, according to the Efficiency Indicators in Primary Care that are periodically evaluated by an internal Management Committee in the Catalan Health Service (macromanagement level).<sup>18</sup>

### Data source

The study used population data from 2008, 2009 and 2010 Catalonia censuses.<sup>17</sup> Records of billed prescriptions were also utilized, based on both paper and electronic prescriptions that were dispensed in community pharmacies and charged to the Catalan Health Service. This information was obtained by means of the personal healthcare card, the document that provides citizens with access to the centres, services and benefits of the public health system (these services include drugs subsidised by the Catalan Health Service).<sup>1</sup> This information is stored monthly in a computer system, which allows the design and gathering of information required for the management and monitoring of pharmaceutical services.

Prescriptions in paper format are usually issued for 3 months ("chronic patients program" in primary care setting) and electronic prescriptions are usually issued for 12 months (maximum); at least once a year patients visit the doctor to renew them.

Polymedicated users were selected monthly, so polymedicated population varied throughout the whole study (28 months, which involved 28 data analysis). Due to the fact that each user had its own identification code, given by the personal healthcare card, subsequent analyses could be carried out so as to determine monthly duplicities of users.

### Ethical statement

Ethics approval was not required since it was a secondary analysis of suitably anonymised datasets. It was not an experimental treatment, patients were not recruited. ~~was not required to undertake this study.~~ The study was unfunded.

### Variables of the study

The variables used to analyze the implementation of e-prescription were as follows.

Territorial: number and % of BHAs implemented, % of primary care centres implemented, grade of implementation, number of general practitioners (e-prescription prescribers), % of general practitioners implemented, number of community pharmacies which dispensed electronic prescriptions and % of community pharmacies implemented. Grade of implementation is the percentage of electronic prescribing on the total number of prescriptions billed (sum of prescriptions on paper and electronic format) for a given month or a specific time period (cumulative implementation grade). Depending on the variable described, the grade of implementation is indicative of the deployment of electronic prescription in the territory (i.e. in a given BHA) or the percentage of electronic prescriptions prescribed to an individual in a given period. Demographic: number and % of users implemented, % of users with more than 50% of electronic prescriptions and % of users with more than 90% of electronic prescriptions, number of polymedicated users implemented. By definition it is assumed that total percentage of users with electronic prescription includes those users with more than 50% and 90% implementation of electronic records, and that those users with more than 90% implementation rates are consequently also included in the user group with implementation greater than 50%.

Consumption: number of total prescriptions (sum of prescriptions on paper and electronic format), number and % of electronic prescriptions, and total cost of medications dispensed. Total cost refers to the total cost of medications dispensed (the amount of reimbursement by the Catalan Health Service plus the out-of-pocket amount paid by patients). Drug use indicators were calculated from the following variables: number of prescriptions per polymedicated user (total and electronic format), total cost per polymedicated user and total cost per prescription.

**Literature review**

A systematic search was conducted (April 2014) through the PubMed database to identify the available evidence on electronic prescribing related to polypharmacy and health expenditure or cost analysis. The terms to run the search were located by the vocabulary Medical Subject Headings, with which the articles are indexed in the MEDLINE database. In order to complete this search and extend the results, additional searches combining free terms were also conducted. All search strategies (12) resulted in only 78 references. The studies identified through this search were evaluated by two independent reviewers to assess their inclusion in this document.

## Data processing and statistical analysis

A database was designed. ANOVA and Student's t-tests were used to determine the statistical significance ( $p < 0.05$ ) of the differences using the SPSS version 20.0 statistics program. Regression testing was also performed in order to describe the tendency of the indicators relating to pharmaceutical services.

## RESULTS

### General population

According to internal data in the Catalan Health Service and coinciding with published information,<sup>19</sup> the project achieved the implementation in 273 BHAs, representing 75% of the total territory in 2009. In December 2009, a cumulative total of 16 million electronic prescriptions dispensed were reached, adding more than 800,000 of the insured population and more than 5,000 health professionals (3,289 general practitioners and 2,497 pharmacists). Taking into account the progressive inclusion of primary care teams of BHR in the project during December 2009, the deployment of e-prescribing in primary care settings was considered complete (13% of patients who needed a prescription received an electronic one, 67.4% of which had more than 90% of their dispensed medications through e-prescribing). Therefore, electronic prescriptions could be dispensed throughout Catalonia.

In late 2009, 91% of primary care centers were prescribing electronically and the remaining 9% were under implementation of the tasks prior to incorporation, i.e adaptation of computer applications or training professionals.

During 2009, electronic prescription systems were implemented in 174 BHAs of BHR (82.1% of total BHAs in BHR). In total, 2,255,724 electronic prescriptions were billed, which accounted for 3% of total prescriptions billed. 494,628 users were included (3% of total users with prescriptions in BHR). In the included BHAs, 1,810 general practitioners (47% of total in BHR) prescribed in electronic format, and 95.5% of community pharmacies in the territory dispensed prescriptions of this type.

Out of the 28 BHAs in BHR that implemented electronic prescribing in May 2009, only 6 reached the highest cumulative implementation grade ( $> 25\%$ ) during the period May-December 2009.

General details about the number of total insured users assigned to each of the 6 BHAs and the percentage of total electronic prescriptions during the period May-December 2009 are shown in Table 1.

**Polymedicated users**

Data concerning e-prescription in polymedicated users in these BHAs are disclosed in Table 2. In the 28 months study period, the 6 BHAs met a monthly average of  $169 \pm 31$  (min 89; max 238) polymedicated users. 1,575 polymedicated users were analyzed; 54.4% of them were only polymedicated in 1 month of the study and 4% of them had that condition in  $\geq 10$  months; there were no users being polymedicated during  $> 20$  months.

There was a significant upward trend in the number of polymedicated users, number of prescriptions and total cost ( $p<0.05$ ), comparing the period January 2008-April 2009 with May 2009-April 2010. As depicted in online supplementary appendixes 1-3, the increase in those indicators seem independent from the implementation of electronic prescribing. Individually, 5 of the 6 BHAs showed this increase in those indicators, with the increase being significant in 4 of them ( $p<0.05$ ). On the other hand, prescriptions per user and cost per user showed a decrease between the pre and post implementation period, whereas cost per prescription showed no variation. The decrease in prescription per user and cost per ~~used~~user was evident for both overall and 3 of the 6 BHAs individually, with results being significant in 2 of them ( $p<0.05$ ). A slight upward trend is observed graphically in those 2 indicators prior to the implementation of electronic prescription; after this point the overall trend was decreasing (Figures 1-3).

**DISCUSSION**

In order to explain the results from the study conducted, it should be noted that this is an exploratory and longitudinal study about the implementation and deployment of electronic prescription in polymedicated users belonging to particular BHAs. The fact of studying pharmaceutical services in polymedicated users using new technologies as e-prescription may be important for health authorities because it could allow a step forward in the monitoring of the high costs that they entail and therefore manage chronic care patients more properly.<sup>18 20</sup> Hence this study was designed to describe the tendency of some drug use indicators in the studied population.

It was still early to conduct a proper impact analysis of electronic prescription on all implemented users and population subgroups (by age, gender, pathology, polymedicated users), because it would be essential that total deployment of electronic



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3 prescription and subsequent penetration into the population were fulfilled.<sup>10 21</sup> The  
4 Catalan Health Service considered that the deployment of electronic prescription in the  
5 territory had finished in primary care setting at the time of study, but the truth is that all  
6 BHAs in Catalonia were not implemented. Impact studies could not be carried out until  
7 all BHAs were at least 80% implemented and had between six months and one year of  
8 experience with electronic prescription. In case of insured users, the implementation  
9 criterion could be considered as more than 90% of electronic prescriptions prescribed.  
10 In this sense, results derived from the measurement of indicators suggest previous  
11 approaches in our setting, and are essential to strengthen and guide any future  
12 evaluation of impact in primary care and in those areas where implementation is  
13 developing (specialty care, emergency departments, mental health centers and nursing  
14 homes).

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23 There are currently no national published studies showing results in polymedicated  
24 populations as presented here. In the general population, some autonomous  
25 communities in Spain which have been operating with e-prescription (i.e. Andalusia,  
26 Balearic Islands, Community of Valencia, Galicia) have found that visits to  
27 professionals have been reduced by between 15% and 60% depending on the profile of  
28 the population being observed.<sup>10 22</sup> However, it is difficult to measure in economic  
29 terms the savings to the health system generated by a reduction in the number of visits  
30 as this cannot yet be quantified precisely. What has been determined, although there is  
31 controversy in the published results, is that in many of these communities the switch to  
32 electronic prescriptions coincided with an increase in health spending, as well as in  
33 number of prescriptions issued and total cost per user,<sup>23-25</sup> the latter differing from the  
34 results presented here (a decrease in cost per user between the pre and post  
35 implementation period was observed). The increase in drug expenditure may not always  
36 be significantly related to implementation of e-prescription, and could even be  
37 associated with the personal profile of users included in the e-prescription system and  
38 their health condition<sup>23</sup> (i.e. polymedicated users). Furthermore, specialized reports on  
39 public pharmaceutical expenditure issues show that the fluctuation in the number of  
40 prescriptions always follows a seasonal pattern in Spain.<sup>26</sup> Throughout the year the  
41 number of prescriptions increases in January, June and October, mainly due to visits to  
42 physicians before (June) and after (January and October) the holiday period; this peak  
43 can also be observed for Easter holiday season (i.e. March 2008 and 2010; April 2009).  
44 In addition, during the study period, the increase in prescriptions every April was due to  
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the annual review of the reference pricing system by the government, which reduces the price of drugs from year to year. The new prices came into effect in May and therefore the market share of these products and the turnover rate in pharmacies increased (and consequently the number of patients and billed prescriptions) in the previous month. In either case, it is important to highlight that all these monthly increases are merely transitory and they are irrelevant in the medium-long term evolution of time series, so they do not set a trend only by themselves.

Internationally, there are studies that describe quantitatively the influence of e-prescribing on implementation of pharmaceutical services and other elements of the health system. These results are mainly related to potential savings of e-prescribing (total cost of time taken by the practitioners, medical attendance, less equipment and operational costs).<sup>10-13 27</sup> However, there are none that assess drug use indicators in polymedicated users and therefore comparable to the results obtained in the present study.

Qualitative results were mostly observed in the 6 BHAs selected. Those results were inherent to the development of electronic prescription over the territories (i.e. increase in electronic prescribing and a decrease of the proportion of paper prescriptions). However, it is important to highlight some quantitatively different aspects have been significant since the introduction of electronic prescribing in the territory in May 2009. This includes the decrease in the number of prescriptions per user, and total cost per user. In contrast, there was an increase in the number of prescriptions and the total cost, which could be attributed to the progressive deterioration of polymedicated users' health and the consequent need for more complex treatments such as the prescribing of therapeutic innovations, which are more expensive. In addition, duplication in the dispensation (due to coexistence of paper and electronic prescriptions in the same user) was also suggested as cause of that increase.<sup>28</sup> It is noteworthy that the results of any health intervention begin to appear at least one year after its start, and in this regard it would be necessary to assess the evolution over the years 2010 and 2011 to see whether there are more significant changes on any of the measured indicators. The implementation of electronic prescribing was a dynamic process that followed different patterns depending on the time (different degree of implementation throughout the development, period of adaptation to the new tool), territory, providers (often there was variability between providers and even within the same provider), type of users (polymedicated/non polymedicated, by age group, etc), and healthcare professionals,

among others, which will hinder future development of common profiles and design a model of this implementation globally.<sup>28 29</sup> However, there were other specific factors that more directly influenced one of the indicators analyzed: the case of the total cost (per user and per prescription), which could be affected by policies of rationalization of medication (generic prescribing, standardized protocols)<sup>30 31</sup> and changes in drug pricing (review of medication prices by the government), among others.

### Study limitation

This is an exploratory, longitudinal study and may have an inherent bias common to this type of study. Furthermore, the period covered is short to establish causal relationships between e-prescribing and variations in drug use indicators. However, it gives hints of some trends that are essential to conduct future impact assessment studies and it could also provide evidence on this topic. This study was carried out in 6 BHAs because at the time of study they were those BHAs with the greatest implementation grade.

### CONCLUSIONS

**Results suggest that** after the implementation of electronic prescribing (May 2009) ~~in polymedicated users, the rationality of prescribing in polymedicated patients improved the number of prescriptions per user, and the total cost per user decreased.~~

This study provides a very valuable approach for future impact assessment.

The electronic prescribing system allows the closest follow-up of drug use indicators in each stage (i.e. number of prescriptions issued vs. dispensed), so health professionals can control risk patients in terms of rational drug use, improving quality of services and health promotion.

**Contributors** IL-D collected the data, conducted the analysis and wrote the first draft of the manuscript. PM advised on design the study, data analysis and helped revise the draft of the manuscript. PL-C helped in conduct of study and data analysis. CFL helped data analysis and helped revise the draft of the manuscript. JLS contributed expertise in interpretation and analysis and helped revise the draft manuscript. AG-P contributed to design the study and expertise in interpretation and analysis. ELM contributed to the study design, contributed expertise in interpretation and analysis, and assisted in revising the draft manuscript. All authors reviewed and agreed on the submitted version of the manuscript.

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## REFERENCES

1. Government of Catalonia, Health Department. The electronic prescription (Rec@t). <http://www20.gencat.cat> (accessed 10 Jun 2014).
2. Gilabert-Perramon A, López-Calahorra P, Escoda-Geli N, *et al.* Electronic prescription in Catalonia, Spain (Rec@t): a health tool. *Med Clin (Barc)* 2010;134(Suppl 1):49-55.
3. Decree 159/2007, of 24 July, which regulates electronic prescription and telematic processing of pharmaceutical services in charge of Catalan Health Service. DOGC num. 4934, of 26-07-2007, pp. 25.620-2. <http://www.gencat.cat> (accessed 10 Jun 2014)
4. Ammenwerth E, Schnell-Inderst P, Machan C, *et al.* The effect of electronic prescribing on medication errors and adverse drug events: a systematic review. *J Am Med Inform Assoc* 2008;15:585-600.
5. Van Doormaal JE, Van den Bemt P, Zaal RJ, *et al.* The influence that electronic prescribing has on medication errors and preventable adverse drug events: an interrupted time-series study. *J Am Med Inform Assoc* 2009;16:816-25.
6. Weingart SN, Massagli M, Cyrulik A, *et al.* Assessing the value of electronic prescribing in ambulatory care: A focus group study. *Int J Med Inform* 2009;78:571-8.
7. Lapane KL, Dubé C, Schneider KL, *et al.* Patient perceptions regarding electronic prescriptions: is the geriatric patient ready? *J Am Geriatr Soc* 2007; 55:1254-9.
8. Porteous T, Bond C, Robertson R, *et al.* Electronic transfer of prescription-related information: comparing views of patients, general practitioners, and pharmacists. *Br J Gen Pract* 2003;53:204-9.
9. Ministry of Health, Social Services and Equality. Project: Electronic prescription in the NHS (June 2014). <http://www.msssi.gob.es> (accessed 10 Jun 2014).
10. European Commission, information society and media. Case studies. <http://www.ehr-impact.eu> (accessed 10 Jun 2014).
11. Government of Balearic Islands. Electronic prescription in Balearic Islands (Jan 2010). <http://www.recetaelectronicaibaleares.es> (accessed 10 Jun 2014).
12. Cannaby S, Westcott D, Pedersen CD, *et al.* The cost benefit of electronic patient referrals in Denmark: summary report. *Stud Health Technol Inform* 2004;100:238-45.

13. National Prescribing Centre, NHS. Saving time, helping patients: A good practice guide to quality repeat prescribing (Jan 2004). <http://www.npci.org.uk> (accessed 10 Jun 2014).

14. European Patients Smart Open Services. Welcome to epSOS-a European eHealth Project. <http://www.epsos.eu> (accessed 10 Jun 2014).

15. Mäkinen M, Forsström J, Äärimaa M, *et al.* A European survey on the possibilities and obstacles of electronic prescriptions in cross-border healthcare. *Telemed J E Health* 2006;12:484-9.

16. De La Puente ML, Fusté J. Health Map: a dynamic vision of health service planning in Catalonia, Spain. *Med Clin (Barc)* 2008; 131(Suppl 4):3-8.

17. Official statistics website of Catalonia (Idescat). Statistical yearbook of Catalonia. <http://www.idescat.cat> (accessed 10 Jun 2014).

18. Lizano-Díez I, Modamio P, López-Calahorra P, *et al.* Profile, cost and pattern of prescriptions for polymedicated patients in Catalonia, Spain. *BMJ Open* 2013;3:e003963.

19. Lizano I, Carbonell P, López P, *et al.* Impact of electronic prescription on users and the health system in Catalonia. *Gac Sanit* 2010; 24(Espec Congr 1):29.

20. World Health Organisation (WHO). Preventing chronic diseases, a vital investment. Department of Chronic Diseases and Health Promotion. Geneva, 2005. [http://www.who.int/chp/chronic\\_disease\\_report/en/](http://www.who.int/chp/chronic_disease_report/en/) (accessed 10 Jun 2014).

21. Hillestad R, Bigelow J, Bower A, *et al.* Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. *Health Aff (Millwood)* 2005;24:1103-17.

22. Suárez-Varela J, Beltrán C, Molina T, *et al.* Computer-aided prescribing: from utopia to reality. *Aten Primaria* 2005;35:451-9.

23. Mateu J, Boronat MA, Zaforteza M, *et al.* Electronic prescription: impact on pharmaceutical expenditure. *Gac Sanit* 2011;25(Espec Congr 1):7.

24. Calzón S, Mercader JJ, Montero JC, *et al.* Introduction of the electronic prescription in a primary care district: impact on pharmaceutical expenditure and the factors determining its use. *Aten Primaria* 2013;45:133-9.

25. Catalán-Arlandis, JL. The computerised prescription in Primary Care and its impact on drug spending using time series analysis. *Rev Calid Asist* 2011;26:18-27.

26. Farmaindustria. The pharmaceutical market in Spain. April 2009; Bulletin 48. <http://www.farmaindustria.es> (accessed 10 Jun 2014).

- 1  
2  
3 27. McMullin ST, Lonergan TP, Ryneerson CS. Twelve-month drug cost savings  
4 related to use of an electronic prescribing system with integrated decision support  
5 in primary care. *J Manag Care Pharm* 2005;11:322-32.  
6  
7  
8 28. Acezat Oliva J. Impact of the use of ICT on pharmacy costs. The incorporation of  
9 the electronic prescription. *Aten Primaria* 2013;45:139-40.  
10  
11 29. Amirfar S, Anane S, Buck M, *et al.* Study of electronic prescribing rates and  
12 barriers identified among providers using electronic health records in New York  
13 City. *Inform Prim Care* 2011;19:91-7.  
14  
15 30. Crosson JC, Isaacson N, Lancaster D, *et al.* Variation in electronic prescribing  
16 implementation among twelve ambulatory practices. *J Gen Intern Med*  
17 2008;23:364-71.  
18  
19 31. Fischer MA, Vogeli C, Stedman M, *et al.* Effect of electronic prescribing with  
20 formulary decision support on medication use and cost. *Arch Intern Med*  
21 2008;168:2433-9.  
22  
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Table 1 Detail on the number of total users, prescriptions and percentages in the 6 BHAs of study during the period May-December 2009.

BHAs of prescription	Total users	Total prescriptions	Average number of prescriptions per user	% Electronic prescriptions*	Users with electronic prescriptions†	% Users with electronic prescriptions‡	% Users with > 50% of electronic prescriptions‡	% Users > 90% of electronic prescriptions‡
BHA 1	107,306	438,228	4.08	42,03%	35,000	32.62%	28.55%	21.03%
BHA 2	55,776	293,860	5.27	37,69%	20,593	36.92%	32.75%	24.74%
BHA 3	72,484	329,073	4.54	33,81%	24,100	33.25%	29.55%	23.41%
BHA 4	43,731	191,705	4.38	32,96%	14,346	32.81%	28.32%	21.97%
BHA 5	72,585	351,972	4.85	29,57%	23,274	32.06%	28.18%	22.10%
BHA 6	53,511	264,308	4.94	25,06%	13,142	24.56%	21.08%	15.14%
Total	405,393	1,869,146	4.61	34.20%	130,455	32.20%	28.20%	21.50%

\* % Electronic prescriptions = (Total electronic prescriptions/Total prescriptions)\*100 = % Cumulative implementation grade (>25%)

† Users with electronic prescriptions: Users with, at least, one electronic prescription

‡ % Users with electronic prescriptions = (Users with electronic prescriptions/Total users)\*100

Results were calculated from global cumulative data in each BHA

Table 2 Detail on the number of polymedicated users, prescriptions and related drug use indicators in the 6 BHAs during the post-implementation period May 2009-April 2010.

BHAs of prescription	Polymedicated users	Electronic prescriptions	Total prescriptions	% Electronic prescriptions *	Average number of prescriptions per polymedicated user	Average cost per polymedicated user	Average cost per prescription
BHA 1	241	11,708	18,243	64.18%	30.71 ± 3.01	€ 404.02 ± 48.25	€ 13.28 ± 1.89
BHA 2	112	7,497	12,149	61.71%	31.44 ± 1.97	€ 455.69 ± 48.80	€ 14.52 ± 1.53
BHA 3	297	6,099	11,976	50.93%	29.65 ± 2.82	€ 467.32 ± 70.36	€ 15.73 ± 1.38
BHA 4	275	1,995	4,026	49.55%	30.57 ± 3.83	€ 500.14 ± 88.99	€ 16.41 ± 2.34
BHA 5	284	3,796	10,133	37.46%	30.70 ± 1.56	€ 503.95 ± 70.23	€ 16.41 ± 2.02
BHA 6	366	1,322	5,554	23.80%	32 ± 3.36	€ 450.74 ± 50.30	€ 14.10 ± 0.79
<b>Total</b>	<b>1,575</b>	<b>32,417</b>	<b>62,081</b>	<b>52.22%</b>	<b>30.73 ± 1.96</b>	<b>€ 454.03 ± 35.22</b>	<b>€ 14.79 ± 0.98</b>

\* % Electronic prescriptions = (Total electronic prescriptions/Total prescriptions)\*100

Averages of monthly global data in the 6 BHAs were calculated for prescriptions/user, cost/user and cost/prescription

All data included made reference to the whole prospective follow-up period (average data resulting from 12 months, post-implementation period)



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**FIGURES**

Figure 1 Evolution of number of prescriptions per polymedicated user in the 6 BHAs of study

Figure 2 Evolution of total cost per polymedicated user in the 6 BHAs of study

Figure 3 Evolution of total cost per prescription in polymedicated users in the 6 BHAs of study

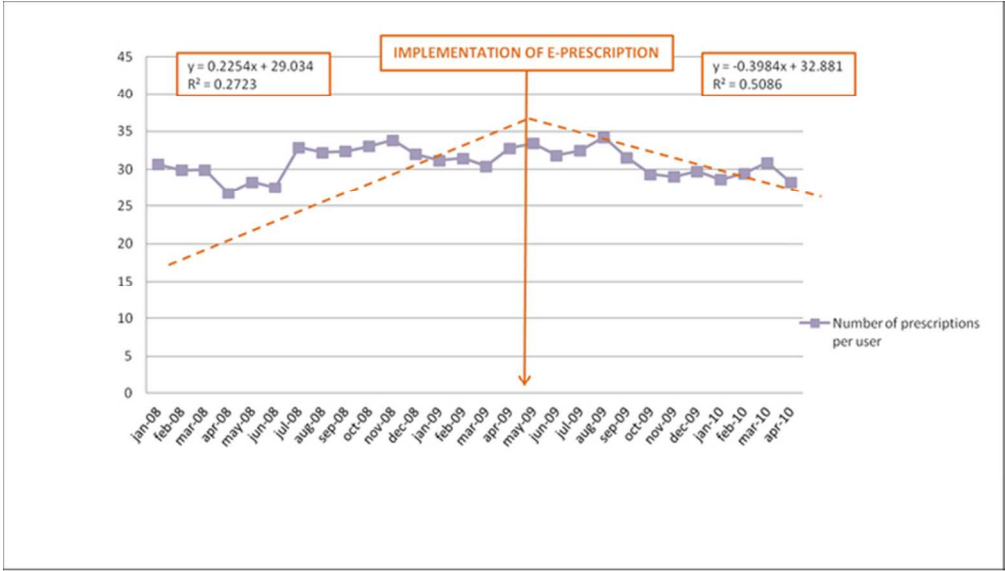
For peer review only

## Online Supplementary appendices

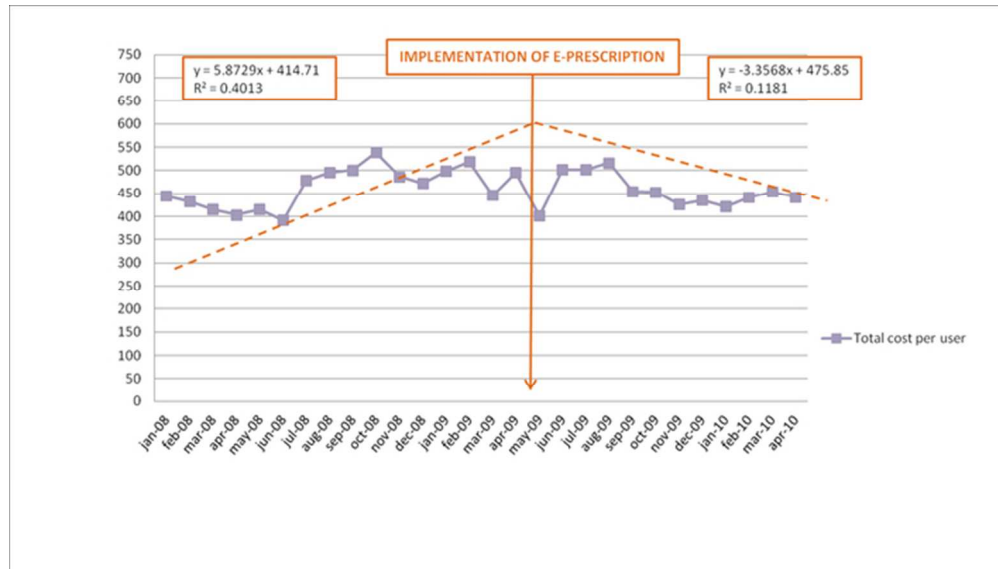
Appendix 1 Evolution of growth in number of polymedicated users in the 6 BHAs of study

Appendix 2 Evolution of number of prescriptions in polymedicated users in the 6 BHAs of study

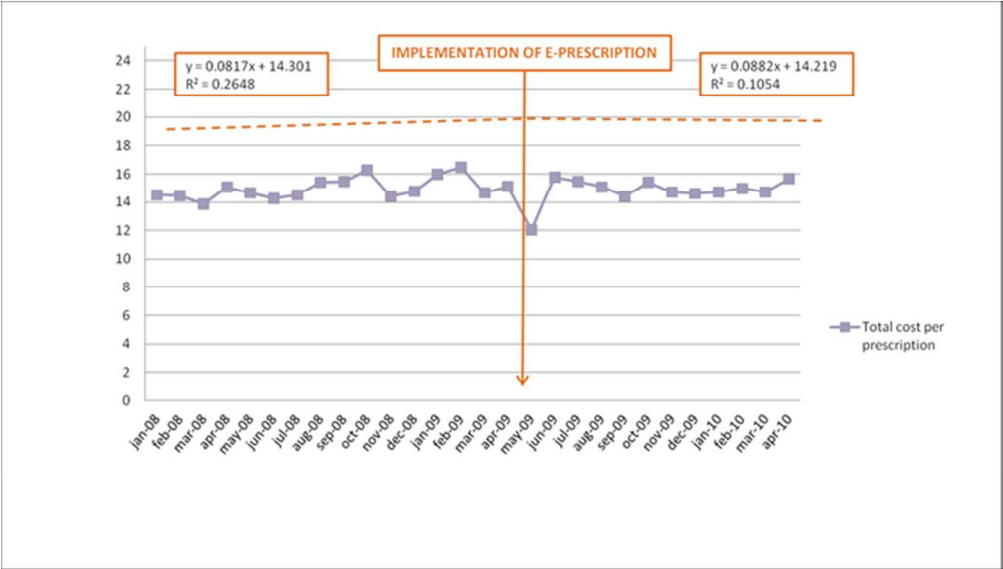
Appendix 3 Evolution of growth in total cost in polymedicated users in the 6 BHAs of study



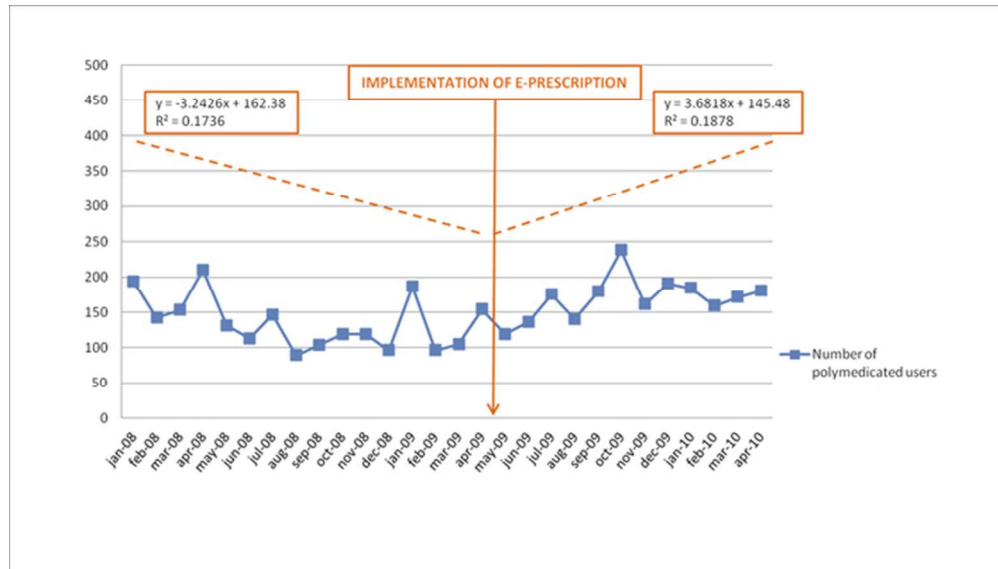
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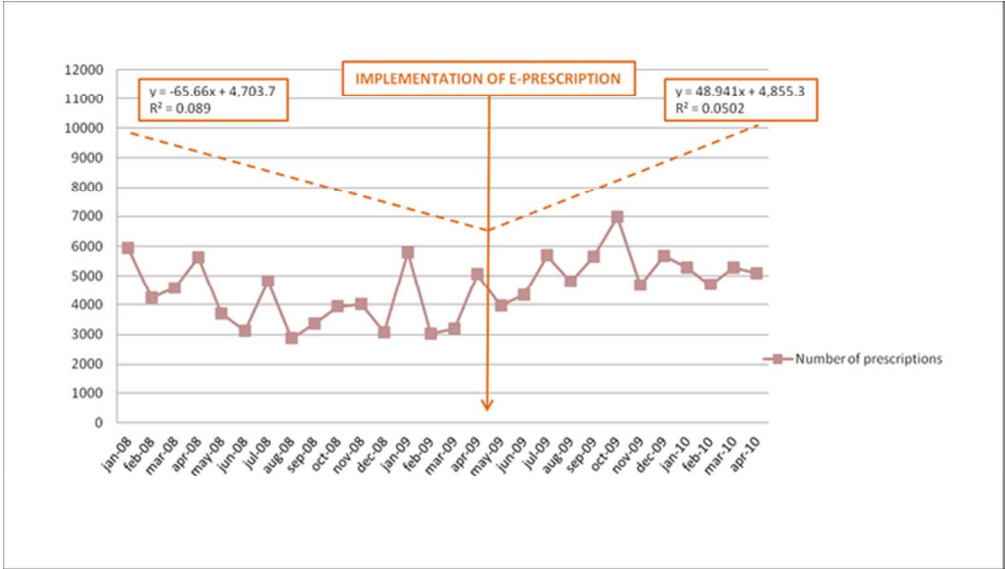
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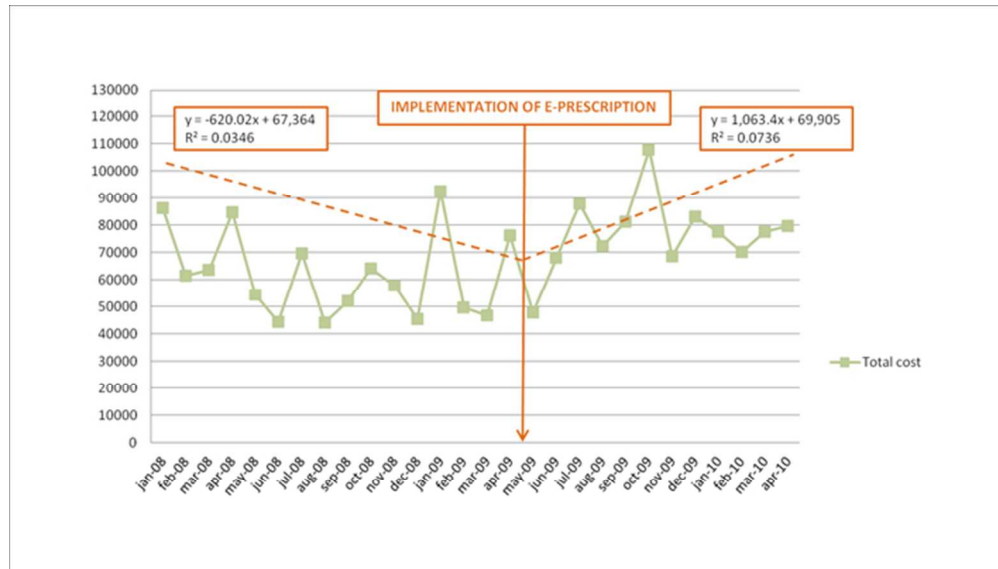
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